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ORIGINAL ARTICLES.

I.—Notes on British Dinosaurs. Part II: *Polacanthus*.

By Dr. Francis Baron Nopcsa.

(PLATE XII.)

NEXT to *Hypsilophodon*[1] it was *Polacanthus* which attracted my attention. A careful study soon showed that, after the death of the animal, the remains of some Crocodilian had accidentally become commingled with this Dinosaur. Besides this, some pieces, namely, the back part of a skull and a cervical, showed remarkably *Iguanodon*-like characters, and the same is also true of the pubic bone described by Seeley in 1892 as belonging to *Polacanthus*.

As I intend pointing out further on, and as has also already been done by Seeley, *Polacanthus* was constructed essentially after the *Struthiosaurus* plan, and this is the reason why this *Iguanodon*-like basi-occipital has to be removed from the *Polacanthus* remains.

For the removal of the pubic bone from the genus *Polacanthus*, similar arguments can be brought forward.

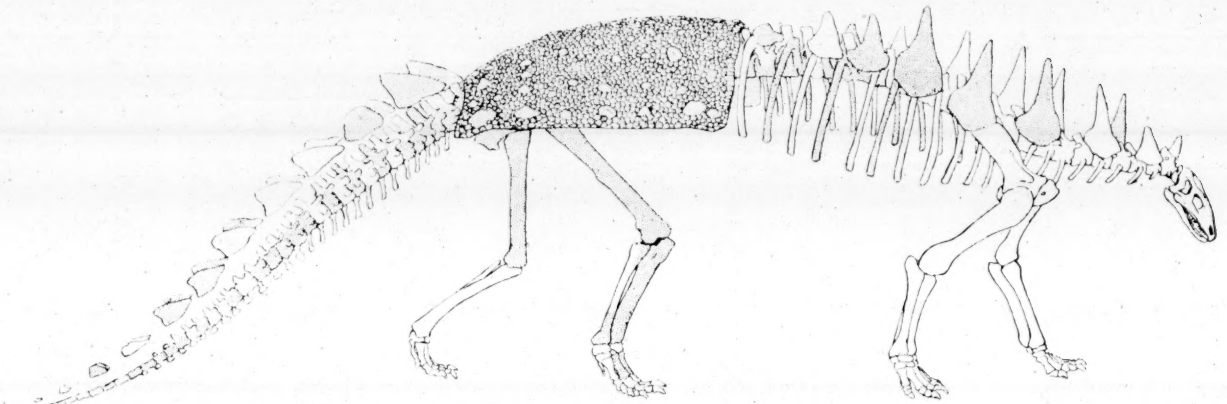
(1) The ischium and pubis are two closely correlated bones, and as the ischium of *Polacanthus* is totally different from that of *Iguanodon* the same was to be expected as to the pubis.

(2) Both ischium and pubis are correlated with locomotion, and as *Iguanodon* was a bipedal and *Polacanthus*, on the contrary, a quadrapedal animal, we again cannot expect *Polacanthus* to have an *Iguanodon*-like pubis.

Since the so-called *Polacanthus* pubis differs from *Iguanodon* only by being somewhat shorter,[2] and agrees very well with the *Iguanodon*-like basis cranii and cervical vertebræ, I think it may quite well belong to an *Iguanodon*-like animal, and not to *Polacanthus*.

[1] For *Hypsilophodon*, see Geol. Mag., May, 1905, pp. 203–208.

[2] Even this *may* be due to fracture.



Reconstruction of the skeleton and bony dermal armour of *Polacanthus Foxi*, Hulke.

Wealden: Isle of Wight. Set up in the Geological Department, British Museum (Natural History).

After these preliminary remarks one can determine as belonging to *Polacanthus*—

4 free dorsal vertebræ,
11 co-ossified vertebræ, forming together with ribs and dermal armour the lumbo-sacral shield,
19 caudal vertebræ,
7 right, 3 left } ribs,
2 femora,
1 right tibia with fragment of fibula,
1 right (?) metatarsal bone,
3 left, 5 right } dorsal spines,
8 left, 6 right } upper caudal plates,
some plates of uncertain position,

and besides these numerous fragments. Comparing these data with those given by Fox, one remarks that only some metatarsals, phalanges, and dermal spines are missing.

Vertebræ.

Although the vertebræ have been described by Hulke, still I think some characters have not been clearly brought out; moreover, a comparison between the vertebræ of *Polacanthus* and other Dinosaurs is still entirely wanting. To Hulke's description of the foremost dorsal vertebræ scarcely anything has to be added, except the facts that the fractured surface of the spinous process shows a quadrate outline, that the neural canal shows lateral compression, that the præ- and postzygapophyses are remarkably near the median line of the body, and that the postzygapophyses project rather far backwards.

Taking into consideration that only 4 free dorsal vertebræ are present, while one can count not less than 7 ribs belonging to the right side, and that between the first and second of these ribs a considerable difference is observable, it is obvious that *Polacanthus* possessed at least 8 free dorsal vertebræ, so that together with the 5 anchylosed lumbodorsal vertebræ the back of *Polacanthus* consisted of at least 13 vertebræ, and assuming the presence of at least 7 cervical vertebræ, this accords well with the number of vertebræ in *Scelidosaurus* (22), while in the reconstruction of *Stegosaurus* 24 vertebræ are given. In *Triceratops* still more vertebræ seem to have been present. At all events the back of *Polacanthus* must have attained a length of 90–100 cm. This dimension will prove of great value in the reconstruction of the dermal armour.

Compared with other Dinosaurs it is, as already mentioned, *Struthiosaurus* to which the dorsal vertebræ of *Polacanthus* show the most remarkable resemblance, and this is the reason why near Fig. 1, representing a dorsal vertebra of *Polacanthus*, a sketch of a *Struthiosaurus* vertebra is also given. There seems, furthermore, some affinity to exist with the vertebræ of *Omosaurus*, while there are no points of resemblance between our animal and the North

American *Triceratops*, the vertebræ of the latter being much more abbreviated and transversely expanded. The dorsal vertebræ of the highly interesting *Stegoceras* and *Stereocephalus* are yet practically unknown.

Compared with *Scelidosaurus* and *Stegosaurus* there exists a remarkable difference, for in the former the diapophyses are given off at a much lower point than in *Polacanthus*, while *Stegosaurus* seems to exaggerate this elevation of the diapophyses which separates *Polacanthus* from *Scelidosaurus*. In a future paper on *Dacentrurus* I intend to come back once more to this question, and I shall try to show why this elevation of the neural arch (visible also in fossil South American sloths) was developed. Here I only wish to draw attention to the fact that in a recent paper (Ann. Mag. Nat. Hist., 1904) Professor Seeley tries to explain this elevation by the upward pressure of the lungs against the neural spines. The anchylosis of the lumbar vertebræ, a unique feature among Dinosaurs, strongly reminds one of the same character in *Glyptodon*,

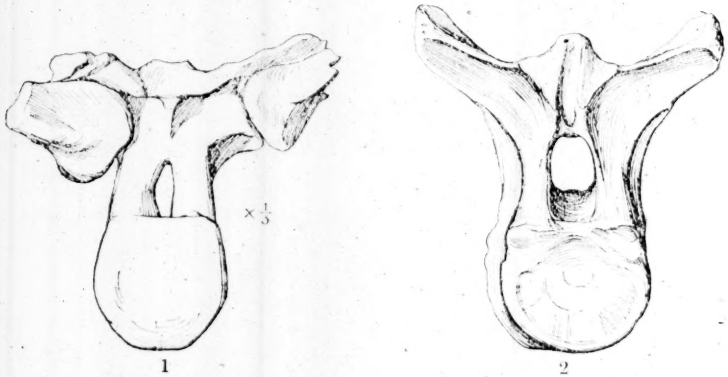


Fig. 1.—Dorsal vertebra of *Polacanthus*, posterior view.
,, 2.—Dorsal vertebra of *Struthiosaurus*, posterior view.

and may be explained as subserving the very same purpose. Hulke's description is equally satisfactory for the sacral as for the lumbar region of the body. The inter-vertebral position of all sacral ribs is, however, a fact worth while mentioning once more.

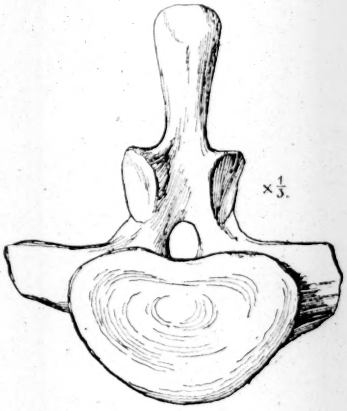
There does not seem to exist any especial widening out of the neural canal in the sacral region, as recorded for *Stegoceras*, and also visible in *Dacentrurus* (*Omosaurus*).

Concerning the caudal vertebræ, there is, first of all, the curious fact to be noted, that while Fox originally mentioned 20 vertebræ and I myself managed to count 19 distinct centra Hulke mentions only 13, so that for some time 6 were apparently missing.

As Hulke points out, the proximal caudal (Fig. 3) are much broader than high, and have, in consequence of the neural canal being partly lodged in the centrum, a somewhat depressed heart-shaped outline. At the same time they are much shorter than the

dorsals and lumbars, and in consequence have an abbreviated appearance. The processus transversi are given off from the centrum, and are pointed nearly horizontally outwards. A similar abbreviated and expanded structure of the centrum may be observed on some, not yet described, *Dacenturus*-like vertebræ in the Havre Museum. I therefore think the original shape of the proximal caudals in *Polacanthus* has been only slightly disfigured by pressure. The neural spine is not very long, but very thick, and the præ- and low præ- and postzygapophyses do not project far out over the articular surfaces of the centrum.

The median caudals differ by having a less depressed, less expanded, and more elongate centrum, and the diapophyses directed downwards and outwards. The neural canal is much smaller, the chevron bone articulated nearly entirely with the hind part of the centrum, there being scarcely any impression for its articulation on the anterior margins.



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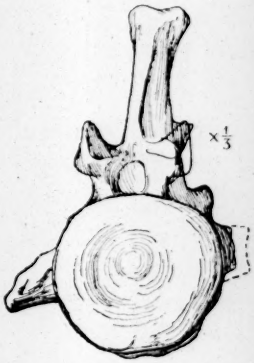

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Fig. 3.—Proximal caudal of *Polacanthus*, posterior view.
,, 4.—Middle caudal of *Polacanthus*, anterior view.

Further back, towards the end of the tail, the vertebræ become still more elongate, and the front articular surface, which was slightly concave in the anterior and median caudals, becomes decidedly convex. The posterior surface remains concave throughout the whole vertebral column. In Figs. 4 and 5 sketches of middle and posterior caudals are given.

Until now only one chevron bone of *Polacanthus* has been detected, but this one is quite characteristic. The top view shows a nearly quadratic section, and at its distal end its thickness is about twice that of its antero-posterior dimensions. Both rami are exceedingly strong, and in accordance with the general massive structure of the tail.

There is a striking resemblance between the root of the tail of *Polacanthus* and that of the gigantic *Megatherium*; the rest of the tail has, however, been reconstructed after the *Hylæosaurus* pattern.

Femur.

The femur of *Polacanthus* differs by its proximal and distal expansion very markedly from the same bone in *Dacenturus*, *Stegosaurus*, or even, though less so, from *Scelidosaurus*, and can only be compared with *Struthiosaurus* from the Gosau formation. Among mammalia it is not with the Proboscidea that the *Polacanthus* femur should be compared, but rather with *Dinoceras*, and this is of no small interest, since it is the Proboscidean femur that the femur of the Stegosaurians and Sauropoda seems to have imitated. In my forthcoming *Dacenturus* paper I intend to ventilate also this question which, to a certain extent, has already been noticed by the late Professor Hatcher.

Dermal Armour.

As Hulke mentioned in 1881 and 1887, one can distinguish in the dermal armour of *Polacanthus* flat plates which are united by synostosis and form a buckler covering the sacrum and the lumbar region; besides, there are small button-like round scutes which, as in *Hylæosaurus*, belong to the end of the tail; then there are keeled

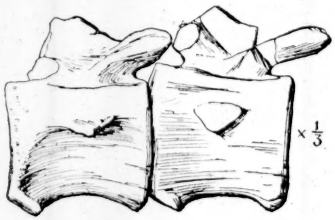


Fig. 5.—Two of the posterior caudals of *Polacanthus*, side view.

high roof-like scutes which also belong to the caudal region, further on heavy spines rising from a flat triangular base, and besides this large oval plates which show a rounded keel near the middle. It can be seen that in this particular the dorsal ossifications of an animal show a great amount of specialisation.

The sacrolumbar buckler is well known, being figured and described by Hulke in a supplementary note in 1887. It is to be noticed that the anterior margin is thinned out, thus indicating that the abrupt anterior end is not due to fracture.

Some other points have, however, till now entirely escaped attention. In Hulke's figure in 1887, plate 9, the last lumbar ribs are drawn as if a thinning out towards the margin were to be expected. This is, as an inspection showed, and as Seeley already pointed out in his sketch of the *Polacanthus* pelvis, not the case, but the ribs terminate nearly at the median dorsal margin of the ilium, or are extended somewhat beyond and above the præacetabular process of the ilium. As Professor Seeley has already pointed out, the structure of the ilium bears a remarkable resemblance to the same part in *Omosaurus* and *Stegosaurus*, but I do not think it is dessication, as Seeley modestly puts it, to which we owe since 1892 the visibility of the

iliac bone in *Polacanthus*, but I rather think we owe this simply to the Professor's keen eye and intimate knowledge of Dinosaurian structure. Until now, however, though already mentioned and figured by Hulke, no attention has been paid to the fact that across all the dorsal and sacral ribs ossified tendons (ligaments ossified) extend which show a considerable amount of disturbance, and thus clearly prove that they have not been co-ossified either with the superimposed dorsal armour or with the underlying ribs. This alone shows, apart from all other physiological considerations, that right and left from the median dorsal line the dorsal armour was not co-ossified with the ribs, and if co-ossification did occur it could only have happened on the surface of the ilia and along the summits of the neural spines. Through this indication there appears to exist a still greater resemblance between the so-called '*Danubiosaurus*' bone of Gosau and *Polacanthus*, because also in that one a median empty space seems to have separated the underlying rib-like bone. As Professor Seeley has likewise mentioned, the iliac bone extends laterally somewhat beyond the lumbosacral shield.

Besides the dorsolumbar shield Hulke distinguished in his second *Polacanthus* paper three types of dermal armour. The roof-like plates Hulke supposed to be situated *à cheval* above and below the hæmal and neural spines, while the spines were believed to be situated somewhere on the thoracic region, and flat shields are supposed, according to Fox's interpretation, to have covered the belly.

Since the dermal covering of no Stegosaurid animal is yet perfectly known, and the figure Marsh gives of *Scelidosaurus* does not seem quite correct in this regard, it seems at first rather difficult to decide these questions, but having been able to investigate, besides *Polacanthus*, both *Hylæosaurus* and *Scelidosaurus*, and having fitted in *Polacanthus* numerous new pieces together, I am able to assert that the roof-shaped scutes formed two rows right and left of the neural spines of the caudal vertebræ, and that the highest spines belong to the scapular region.

Before dealing, however, with this problematical armour it is necessary to consider first the nearly perfectly preserved mail of *Scelidosaurus*. On the body of *Scelidosaurus* one can trace out quite distinctly seven rows of dermal ossifications, which show that the back of this animal was covered by a median row of keeled scutes, on the sides of which a smaller row is visible. In this second row the tubercles increase the nearer we approach the sacrum. Laterally of this second row we can distinguish on each side two rows of scutes converging forwards, in each of which the scutes gradually augment in height the more they approach the scapular region, so that meeting at the scapula these two rows at last form only one row of rather tall spine-like ossifications. A good idea of the way they augment in height towards the scapula is given in the otherwise not quite correct reconstruction of *Scelidosaurus* published in the edition of the popular guidebook of the British Museum.

In the sacral region of *Scelidosaurus* the dermal ossifications are

strongly displaced, and it is only in the caudal region that we find them comparatively in order.

On the middle part of the tail one can clearly distinguish three roof-like plates, one placed on each diapophysis of the centrum and one on the neurapophysis of the arch. Further back one can only observe two roof-like, somewhat asymmetrical plates placed laterally of the neurapophysis and above the diapophysis, thus allowing space for the musculus lateralis caudæ. A thicker plate is visible in one place laterally of the chevron bone. In *Diracodon*, *Stegosaurus*, and *Dacenturus* (*Omosaurus*) we know that the end of the tail was protected by a double row of spines, while the anterior caudals and all the other vertebræ supported one median row of high plates, which in consequence of their abrupt posterior margin were pointed somewhat backwards and formed an acute dorsal ridge.

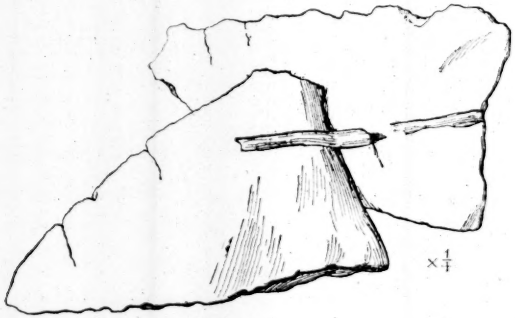


Fig. 6.—One pair of dermal caudal plates of *Polacanthus* (preserved united in matrix), side view.

The probably complex armour of the Ceratopsidæ is altogether unknown, and the same is true for *Acanthopholis* and *Struthiosaurus*. Besides *Scelidosaurus*, *Hylæosaurus* is the only European armoured Orthopodous Dinosaur in which the armour is still partly *in situ*, and though somewhat disturbed, one can notice that this Dinosaur possessed at least two rows of lofty spines which, beginning directly behind the head, increase rapidly in height and attain their maximum development and sharpness in the scapular region. This reminds one to a certain degree of the armour of the Iguana tuberculata. The lumbar region of *Hylæosaurus* is nearly unknown, and in the tail only button-like ossifications seem present.

Turning back to *Polacanthus*, the piece figured by Hulke and fragments which I succeeded in uniting prove that some of the roof-like plates and button-like pieces belong to the armour of the tail. By placing all the roof-like plates in one row beside the caudal vertebræ it soon, however, became evident that this was *not* their natural position, for the row they formed in this way is just about twice as long as the entire series of caudal vertebræ.

This circumstance drew my attention to numerous facts not yet

mentioned. Two such caudal spines measure each 21 cm., two others 19, and so on. Besides this the peculiar features of the two largest, the two next, and so on, is always similar, so that arranging the spines according to the colour and size we get a series attaining the presumed length of the tail of *Polacanthus*. This alone would be enough to prove that the plate-like scutes were arranged in pairs along the tail, but besides this and the comparison with *Scelidosaurus* there is yet another point to prove it.

By carefully uniting some fragments I managed to bring two plates of equal size still united with matrix in close contact with an underlying vertebra, and this piece, as well as the unsymmetrical character of two uncrushed pieces (which prove to be the before-mentioned last pair of scutes), shows that the roof-like plates could not have been arranged in any other manner than

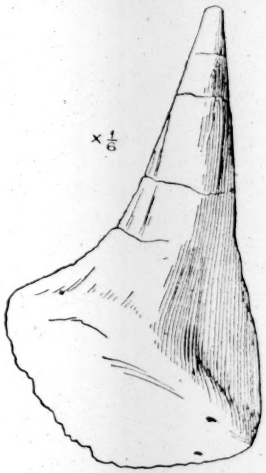


Fig. 7.—Anterior dorsal dermal spine of *Polacanthus*, interior (median) view.

indicated in the reconstruction. Thus the whole top of the tail of *Polacanthus* was covered with two rows of diverging, broad, sharp-edged plates, while the button-like ossicles were distributed between them so as to cover the empty spaces.

In consequence of their great antero-posterior length each of the main scutes was not fixed merely on one but on two or three caudal vertebræ, thus restricting, together with the ossified tendons, the movement of the powerful tail.

Having finished with the tail and its armour, the question where to place the dermal spines (Fig. 7) of *Polacanthus* became quite easy. They could neither belong to the tail nor to the lumbosacral region. They come, therefore, evidently from the anterior part of the body. They are asymmetrical; according to their size they can be arranged in pairs, and the rows thus formed attain a length of 150 cm. Ribs and free dorsal vertebræ show that the thoracic

region of *Polacanthus* measured 90–100 cm., and is thus considerably shorter than the space which these spine-like ossifications cover. Supposing, however, that the spines extended anteriorly right to the back of the skull, as they do in *Hylæosaurus*, and at least 7–8 cervical vertebræ to have been present, this agrees with the length indicated by the double row of spines, and in consequence one cannot help rebuilding *Polacanthus* in a *Hylæosaurus*-like manner.

The coexistence of large, asymmetrical, round, thick, feebly keeled plates, together with the spines in question, shows furthermore that the other, probably more inferior rows of the dermal covering were not formed by spines, but by elements of another type; these are the single pieces that one cannot place *in situ*.

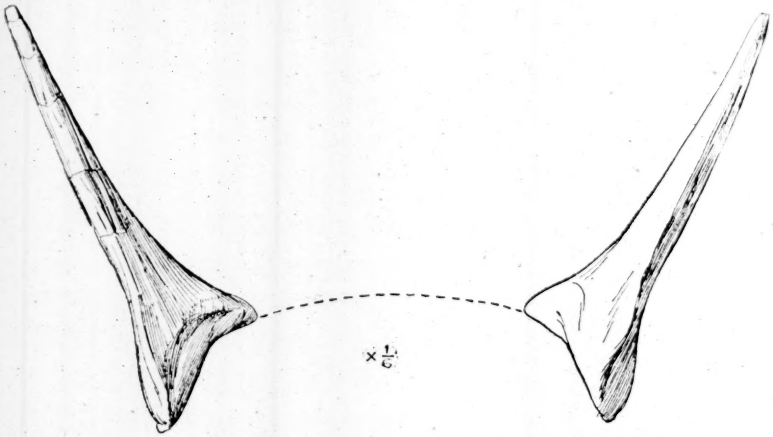


Fig. 8.—Posterior view of a pair of anterior dorsal dermal spines of *Polacanthus*.

Conclusion.

The conclusions drawn from the fresh study of *Polacanthus* are expressed in the reconstruction of the animal as carried out by the 'mason formatori' of the British Museum, Mr. Barlow, under Dr. A. S. Woodward's and my superintendence; and this reconstruction afforded the basis for the Plate accompanying this paper. Through this reconstruction Dr. Hulke's and the Rev. W. Fox's general views about *Polacanthus* are nearly completely in accord. *Polacanthus* was an animal of low stature, whose height at the rump did not exceed three feet. Its strongly marked bones and their large joints speak of its immense muscular power, whilst the shortness of its limbs and the anchylosis of the lumbar vertebræ, welding the loins and the sacrum into a long inflexible rod, give probability to its having been a slowly moving vegetable-feeder. With these characteristics one might venture to add the remark that *Polacanthus* was a sort of Glyptodon among the Dinosaurs.

EXPLANATION OF THE PAGE-PLATE XII.

The shaded parts of the drawing indicate the parts actually preserved; the rest has been reconstructed according to the evidence afforded by *Struthiosaurus*.

II.—On a Collection of Trilobites from the Upper Cambrian of Shantung, North China.

By Henry Woodward, LL.D., F.R.S., F.G.S.

(*Concluded from the May Number, p.* 215.)

(PLATE XIII.)

CONTINUING the notice of Herr H. Monke's paper on the Trilobite-bearing limestone slabs of Yen-tsy-yai, the author observes: — The very dense and solid, slightly arenaceous limestones of Yen-tsy-yai consist of horizontal slabs (from 1–2½ cm. thick) of a dark bluish-grey colour. [p. 109] Whilst showing no traces of fossils in their interior, the limestone slabs are on one side (as shown on pl. ix)[1] often completely covered with the remains of Trilobite carapaces, besides which are found only isolated very minute shells of Brachiopoda. Between them are here and there irregular, lengthened furrows, which may be the tracks of the Trilobites; on the corresponding opposite parts of the slabs are similarly shaped vermiform protuberances. It follows that the fossiliferous side is to be considered as the natural upper part of the slabs. In a certain number of the slabs either both sides or one only are covered besides by a thin argillaceous stratum, which equally contains, though less frequently, delicate remains of fossils; in all the other slabs the fossils present themselves *en relief* and often rest on a small base of limestone, and therefore convey the impression of having been originally covered by a thin argillaceous stratum, which later on was washed away by water.

Where the fossils are covered by the protective argillaceous layer and could be developed by preparation, they are in an excellent state of preservation; where, however, the argillaceous layer is wanting, the fossils are generally much worn and their delicate sculpturing has disappeared. Complete carapaces of Trilobites have not been found; with the exception of a single instance in which seven pleuræ are still united in their original connection, all the carapaces were broken up into single segments; these present themselves mixed together, exhibiting either their superior or inferior side on the upper surface, and are much broken. This condition of things makes it, of course, difficult to find out the parts which belong together; on the other hand, it enables one to study the structure of the carapace in all its details. A close examination revealed the remarkable fact that the remains do not belong solely [p. 110] to adult specimens, but that every possible degree of age, down to individuals of microscopic size, are present in about equal numbers. The explanation of this phenomenon may be that the thin

[1] Our Plate XIII is not copied from Herr H. Monke's beautiful plate, but is taken from *a part* of the fine slab presented to the British Museum by the Rev. Samuel Couling, M.A., Ching-chow-tu, Kiao-chow, China, and was evidently obtained from the *very same quarry* which furnished the slabs forwarded to Berlin by Herr Bergmeister F. Koerter, from the Upper Sinic Limestones of Yen-tsy-yai, where a considerable trade in these slabs, crowded with remains of Trilobites, appears to be carried on by the Chinese, under the title of 'petrified swallows'!

argillaceous layers between the single limestone strata correspond to periods during which the conveyance of fine argillaceous sediments produced a widespread turbidity of the water, so that the Trilobites could take advantage of these periods to undergo their ecdysis whilst protected from the eyes of their enemies.

What besides makes these slabs from Yen-tsy-yai particularly interesting is their surprising agreement with the above-mentioned plate from Peking, as the comparison of our pl. ix with Bergeron's pl. xiii will show; so that the latter might be presumed to come from the same locality (as already mentioned, these slabs are commercial articles in China).[1] However, a closer investigation shows small differences in the fauna, and for this reason I incline to admit that the slab in fact comes "from the mountains north of Peking," where, according to Von Richthofen (op. cit., p. 317), the Sinic strata are abundantly represented in the Nankón chain. There is no doubt that this slab belongs to the same, or approximately the same, geological horizon as those from Yen-tsy-yai. Regarding the other question, whether all the 73 slabs from the latter locality are of the same geological horizon, it may be mentioned here, in anticipation, that almost without exception each of the slabs exhibits representatives of all the species of Trilobites named in the collection, save in the case of some of the rarer forms.

In the memoir by Herr H. Monke, from which we have extracted the foregoing account of the Trilobite-bearing beds of Yen-tsy-yai, the author figures and enumerates the following genera and species, namely:—

1. *Agnostus Koerferi*, gen. et sp. nov., taf. 3, figs. 1–9.
2. *Liostracina Krauseri*, gen. et sp. nov., taf. 3, figs. 10–17.
3. *Teinistion Lausi*, gen. et sp. nov., taf. 4, figs. 1–17.
4. *Teinistion Sodeni*, gen. et sp. nov., taf. 5, figs. 1–4.
5. *Drepanura Premesnili*, Bergeron, taf. 5, figs. 5–19.
6. *Drepanura Ketteleri*, sp. nov., taf. 6, figs. 1–14.
   Embryonal forms, taf. 6, figs. 15–18.
7. *Stephanocare Richthofeni*, gen. et sp. nov., taf. 7, figs. 1–15.
8. [*Stephanocare sinense*, Bergeron (not figured).]
9. *Stephanocare*, sp., taf. 8, figs. 1–4.
   Drepanura Ketteleri (hypostome), figs. 5–6.
   Drepanura Premesnili (hypostome), Bergeron, taf. 8, figs. 7–9.
   Stephanocare Richthofeni (hypostome), taf. 8, figs. 10–11.

Slab (taf. 9). This slab, which agrees most exactly (*even in size*) with that of which a part forms the subject of our Plate XIII,

[1] This seems less surprising when it is borne in mind that the higher classes in China are very great connoisseurs of natural curiosities, which they purchase and cause to be mounted as articles of *bijouterie* and *vertu*. Natural stones of all kinds cut and squared up or cut and polished are sold in the shops of cities in China, often *long distances* from the localities where the specimens were originally obtained. Mr. Crick has referred to this circumstance in connection with the celebrated 'pagoda-stones' (sections of *Orthoceras*), which, being cut into slabs and mounted in frames to form ornamental panels and screens, may now be met with as trade articles in almost any part of China.—H. W.

contains abundant representatives of parts of all the species of Trilobites enumerated above, except *Stephanocare sinense* of Bergeron. It measures 245 × 205 mm.

The slab obtained by the Rev. S. Couling also measures 250 × 205 mm., but the portion photographed and figured only represents about 180 × 112 mm. In order to add to the value of the slab an additional tail of *Drepanura Premesnili*, Bergeron (Fig. 1), has been very carefully inserted by the Chinese lapidary into the slab (see Plate XIII, 3*), though its identity as a species which occurs in this bed from Yen-tsy-yai is vouched for by other pygidia of the same species forming a part of the original slab.

In the form named *Drepanura Ketteleri*, H. Monke (which like *Drepanura Premesnili*, Bergeron, is founded upon detached pygidia and separate and imperfect head-shields, also with elongated cheek-spines), the lateral caudal spines are very much more elongated, and remind one of the very long lateral cheek and caudal spines of *Bathynotus holopyga*, Hall, from the Lower Cambrian (or *Olenellus* zone of Walcott), Western Vermont, North America. [Fauna of the Lower Cambrian, C. D. Walcott, pl. xcv, figs. 1, 1*a*, p. 646.]

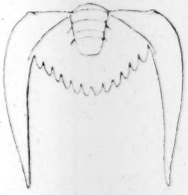


Fig. 1.—Pygidium of *Drepanura Premesnili*, Bergeron. Nat. size. N. Cambrian: Yen-tsy-yai, Province of Shantung, North China.

Stephanocare Richthofeni, of which detached parts are seen upon our slab, Pl. XIII, Figs. 1 and 2, is represented on Herr Monke's plate by six glabellæ, two detached free-cheeks, and three pygidia. There is an element of uncertainty about the correlation of some of these, the underside of the pygidium (figs. 12 and 13) not agreeing very well with the upper side (fig. 11, taf. 7), nor the glabellæ (figs. 1, 2, and 3) with figs. 4, 5, and 6 of the same plate (taf. 7).

I figure, p. 254 (Fig. 2), a detached pygidium preserved on a piece of yellow, compact, fine-grained limestone, which has been polished probably carefully and constantly by hand until it resembles a piece of polished 'soapstone.' It is near to Herr Monke's fig. 11, taf. 7, but either his specimen is unsymmetrical (a very rare occurrence in a Trilobite), or else the artist has drawn the pygidium with six marginal dentations on the left side of the figure and seven on the right, or he intended to indicate that it had one central spine and six marginal spines on each side. In fig. 12, depicting the underside, the artist represents it with six dentations on each side and no central spine. The number of coalesced segments in Herr Monke's fig. 11 is four; in Mr. Couling's specimen, drawn p. 254 (Fig. 2), there are six coalesced segments visible and a small mucro in the centre

with six clearly defined marginal serrations on each side. For this form of pygidium Bergeron[1] adopts Meek's generic name *Olenoides*,[2] with which it certainly agrees most closely. I should venture to suggest to Herr Monke that *Stephanocare* should be merged in *Olenoides* (Meek, 1888) as the older and established name.

The specimen here referred to Fig. 2 (locality uncertain, probably from Shantung) measures 31 mm. in breadth, by 19 mm. in length; the axis is 16 mm. broad at the proximal border, where it once joined the cephalothorax, diminishing gradually to 6 mm. above, where it terminates in a slender, rounded, mucronate point, which merges distally into the dentated border. The pleuræ or lateral lobes of the tail are roundly elevated and elegantly curved, as shown in the two views (*a* and *b*, Fig. 2). They are covered with minute rounded pustules. A shallow groove divides each lobe or coalesced segment of the tail by a smooth and well-marked furrow. The divisions of the axis are rounded and raised, and separated by well-defined grooves.

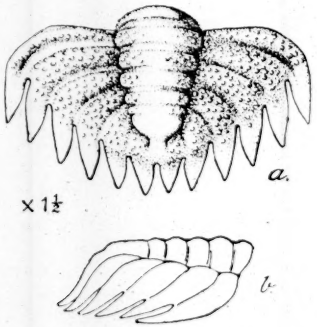


Fig. 2.—*Olenoides Richthofeni?* (Monke), sp. Upper Cambrian (?): Shantung, North China.

It is interesting to notice how closely this form (Fig. 2) agrees with the pygidium of *Olenoides Marcoui*, Whitfield, sp., from the Lower Cambrian of North America (see Walcott, Fauna of Lower Cambrian, pl. xciv, figs. 2*a*, 2*b*, pp. 642 and 575). It also agrees closely with Bergeron's figures and those of Herr Monke's (taf. 7, figs. 11, 12, and 13). Several other pygidia occur on smaller slabs of yellow limestone, obtained by the Rev. S. Couling at Kiao-chow, North China, though not from Yen-tsy-yai, but one of the other fossil-yielding quarries in the Shantung province.[3] There are also some additional Cephalopods which it is hoped may yield further information as to the age of these beds when Mr. G. C. Crick is enabled again to take them up.

It would be very agreeable to review in detail Herr Monke's

[1] "Etude de quelques Trilobites de Chine": Bull. Soc. Géol. France, sér. III (1899), p. 499, t. 27.

[2] American Journal of Science, ser. III (1888), vol. xxxvi, p. 165.

[3] They are probably identical with Bergeron's *Olenoides Leblanci*, op. cit., p. 506, fig. 5, also seen on slab, pl. xiii, fig. 5.

Slab of Limestone covered with remains of Trilobites of Upper Cambrian age, from Yen-tsy-yai, Shantung, China.

Obtained by the Rev. Samuel Couling, M.A., etc.

species from North China, but I feel before doing so the need of better and more complete specimens at my command upon which to found a revision. I can, therefore, only express my thanks to Herr Monke for the valuable work he has accomplished with the very fragmentary material at his command. I have also to tender my best thanks to the Rev. Samuel Couling for entrusting me with all the specimens he was able to obtain and presenting them to the Geological Department of the British Museum (Natural History), Cromwell Road.

EXPLANATION OF PLATE XIII.

The photo reproduction of fossil remains shown on our plate has been taken from a portion of a large slab procured by the Rev. Samuel Couling, M.A., of Kiao-chow, North China, and in age considered by Herr H. Monke to be Upper Cambrian. The slab and its trilobites agree exactly with a number of others obtained for the Royal Prussian Geological Survey and Berg-Akademie in Berlin from Yen-tsy-yai, in the Province of Shantung, North China. Size of original slab, 250 × 205 mm. Size of portion of slab reproduced in plate, 180 × 112 mm. On the slab may be seen examples of the following genera and species, indicated by small figures on the margin of the plate, and in the case of Fig. 1 on the fossil slab itself:—

Fig. 1.—Free-checks of *Stephanocare Richthofeni* (very numerous).
,, 2.—Pygidia of *Stephanocare Richthofeni* (seven examples).
,, 3.—Pygidia of *Drepanura Premesnili*, Berg. (five examples).
,, 4.—Free-cheek with cheek-spine of *Drepanura Ketteleri* (one example).
,, 5.—Head-shields and pygidia of *Agnostus Koerferi* (numerous).
,, 6.—Hypostome of *Stephanocare Richthofeni* (one example).

This slab, together with various other separate Trilobite remains and some Cephalopods, have been presented by the Rev. Samuel Couling, M.A., to the Trustees of the British Museum (Natural History) for the Geological Department.

III.—Note on Fragments of Chert from North China.

By Dr. George J. Hinde, F.R.S., F.G.S.

The fragments of partially weathered chert from North China sent by the Rev. S. Couling,[1] unfortunately without indication of the particular locality or formation where they were collected, are of whitish, slate-grey, or pinkish aspect, and in two instances show traces of banded structure. They consist of cryptocrystalline or microcrystalline silica with small areas in which the silica is of a fibrous chalcedonic character. Remains of organisms can be distinguished in each of the four microscopic sections which have been prepared, but they are generally so shadowy and indefinite that their nature cannot be satisfactorily determined. Some portions of slide marked A are crowded with slender, straight, or slightly curved linear bodies, about ·11 mm. in length by ·01 mm. in width, which in places have a sub-parallel or sheaf-like arrangement. They might be supposed to be sponge spicules, but in their size and disposition they seem to differ from any fossil spicules with which I am acquainted. Slide C largely consists of numerous small, rounded, oval, and conical forms without walls, ranging from ·1 to 1·7 mm. in diameter. In outline and in size many of these

[1] Of Ching-chow-fu, Kiao-chow, Shantung, North China.

bodies might be compared to Radiolaria, but as they are now not sharply delimited from the clear matrix, but by a granular structure without other features, it would be rash to assert, save upon further evidence, that they belong to these organisms. In slide D there are some well-defined circular bodies, ·03 to ·1 mm. in diameter, with clear solid walls, and not infrequently a central spot in each, which very much resemble transverse sections of sponge spicules, and it is possible that this may be their true nature, but some doubt rests on this owing to the apparent absence in the slide of longitudinal sections of spicules.

Though these fragments give fair evidence of a probably organic origin of the chert, it would need carefully chosen specimens of the rock to furnish proof of the nature of the organisms in it.

IV.—On a Displaced Mass of Chalk on the Foreshore of Speeton Cliffs, Flamborough Head.

By B. Hobson, M.Sc., F.G.S.

WHEN revisiting Speeton on the 6th of April, 1905, I was surprised to find that the exposures of Red (Hunstanton) Chalk on the beach at the locality (about 500 yards east of the mouth of Speeton Beck) where the excellent vertical section described by Mr. W. Hill[1] occurs were almost invisible owing to the accumulation of boulders of white chalk by which they were covered. At length I found a small exposure of Red Chalk near low water mark and, within 3 or 4 yards to north of it, that is, seawards, I came across a reef of chalk in well-defined beds, each perhaps 6 or 8 inches thick, weathered to a brownish or drab tint. This chalk, when freshly fractured, was hard and white, quite unlike the true Red Chalk, although practically at the same level. The prevailing dip of the white chalk of the reef was from 25° to 28° to W. 40° S. mg. (= W. 57° S. true), and the length of the exposure along the strike, so far as the limited time at my disposal would allow me to observe, was 65 paces (say 55 yards), the width in the direction of dip being 16 paces (say 13½ yards). So far as I have been able to gather, this reef of white chalk to seaward of, and *apparently* dipping beneath, the Red Chalk has not been described. Four possible explanations of its occurrence may be suggested.

(1) It might be regarded as underlying or forming the base of the Red Chalk. Against this view, the totally different character of the white chalk of the reef from that of the true Red Chalk, and the well-known fact described by Meyer[2] and Lamplugh[3] that the Red Chalk directly overlies Speeton Clay, are conclusive evidence.

[1] W. Hill, "On the Lower Beds of the Upper Cretaceous Series in Lincolnshire and Yorkshire": Quart. Journ. Geol. Soc., vol. xliv (1888), pp. 337 and 345.

[2] C. J. A. Meyer, "Note on the Passage of the Red Chalk of Speeton into an underlying Clay-bed": Geol. Mag., Vol. VI (1869), p. 13.

[3] G. W. Lamplugh, "On the Subdivisions of the Speeton Clay": Quart. Journ. Geol. Soc., vol. xlv (1889), pp. 581, 603, and fig. 8 facing p. 618.

(2) It might be held to be thrown down by a normal fault against the Red Chalk seen 3 or 4 yards to south of it. The only fault shown on the Geological Survey Map, 95 S.E. (published 1881), is one with an east and west strike by which the main mass of the Chalk, north of the village of Speeton, is thrown down on the *south* against the Speeton Clay. Mr. Fox-Strangways[1] remarks: "The junction of the Chalk with the underlying clays is very obscure towards its eastern end; below Speeton and Reighton we have represented the junction by an uncertain line of fault, the principal evidence for which is obtained in the stream running down to the sea below the former village, where there are beds of red and white chalk resting against the thrown up and disturbed Neocomian Clays. There is a great undercliff of Chalk at this point, which much obscures the section, and which might cause the irregularity observed in the beck." Lamplugh[2] remarks: "I think the supposed indications of a fault may be better explained by an ancient foundering of the chalk escarpment, possibly in pre-Glacial times." No white chalk is shown on the Geological Survey map to the north of the Red Chalk. Though the shore reef described in the present note would be more interesting if due to a fault, or (thirdly) to a thrust-plane, such as that described by Dr. Rowe[3] as occurring west of Kit Pape's Spot (to south-east of the reef), the most probable explanation of the present position of the reef appears to me to be the following:—

(4) At some former time when the vertical Chalk cliff near this spot had not been eroded so far back (southwards), the line of cliff lay almost along the present line of junction between the Red Chalk of the beach and the white chalk of the reef. A slip took place by which the white chalk on the north side of the plane of slip was thrown down against the Red Chalk, and subsequent marine erosion has exposed both on the shore. Such a slip in the existing cliff occurs at Crowe's Shoot, of which Lamplugh[4] writes: "There is a huge slip about midway in the Speeton range known as Crowe's Shoot. At this place a great slice of chalk 150 yards long has moved forward and downward for 50 or 60 feet, but has there been arrested, and has remained without further change for over a generation."

It should be added that the comparatively high angle of dip of the chalk in the shore reef and the inconstancy in its amount and direction favour the explanation above given.

[1] C. Fox-Strangways, "The Geology of the Oolitic and Cretaceous Rocks South of Scarborough": Geol. Surv. Mem., 1880, p. 38, and 2nd ed., 1904, p. 89.

[2] See p. 256.

[3] Dr. A. W. Rowe, "The Zones of the White Chalk of the English Coast. Part iv: Yorkshire": Proc. Geol. Assoc., vol. xviii (1904), p. 202.

[4] G. W. Lamplugh, "Notes on the White Chalk of Yorkshire": Proc. York Geol. and Polyt. Soc., vol. xiii (1896), pt. 2, p. 175.

V.—On *Stomatopora antiqua*, Haime, and its related Liassic Forms.

By W. D. Lang, M.A., F.Z.S., F.G.S., of the British Museum (Natural History).

(WITH A FOLDING TABLE I AND PLATE XIV.)

STOMATOPORA ANTIQUA was first described and figured by Haime[1] from specimens occurring on *Gryphæa* in the Lower Lias of France. I have not been able to find any record of an English specimen except that in the Survey memoir on the Lias of England and Wales.[2] But recently several specimens of a *Stomatopora* resembling *S. antiqua*, Haime, were found in the collection of the late Mr. R. F. Tomes. The fact that all the specimens were encrusting *Gryphæa* is remarkable; for though many hundred specimens of various molluscs from the Lower Lias were searched, and of these all sorts of oysters with especial care, *Gryphæa* was the only form encrusted by *Stomatopora*.

In the British Museum catalogue[3] *S. antiqua*, Haime, is made a synonym of *S. dichotoma* (Lamouroux),[4] a Bradfordian form. But an examination of the material alluded to, of which more than a dozen zoaria were sufficiently well preserved to admit of measurements of portions of them after the method described in a former number,[5] has shown not only that this form is a distinct species, but that it exhibits features which make it probable that it is more primitive than any other Jurassic *Stomatopora* as yet described. Even Gregory included it with some hesitation in *S. dichotoma*, for in writing of that species he says[6]: "The one [form] in regard to which I feel most doubt is *S. antiqua*, Haime, from the Lower Lias. Haime founded this practically only on variations in the branching of the lines of the zoœcia. This character is shown by the large series of specimens in the British Museum collection to be of little value. The peristomes are not so much raised as in the typical form, but in this character likewise there are such variations in the same zoarium that the difference is not sufficiently well marked." The systematic value of the two characters mentioned has been discussed in the paper[7] just quoted, in which the author attempts to show that the branching is of paramount importance.

It seems advisable, having the material in hand, to define the species with greater exactness, revising Haime's definition, and by investigating the stages of growth to gain some idea of its relations to other forms.

[1] J. Haime, "Description des Bryozoaires Fossiles de la formation Jurassique": Mémoires de la Société Géologique de France, ser. II, vol. v (1854), pp. 162–163.
[2] H. B. Woodward: "The Lias of England and Wales," 1893, p. 365.
[3] J. W. Gregory: British Museum Catalogue of Jurassic Bryozoa, 1896, p. 44.
[4] J. Lamouroux: "Exposition Méthodique des genres de l'ordre des Polypiers," 1821, p. 84, pl. lxxxi, figs. 12–14.
[5] W. D. Lang, "The Jurassic Forms of *Stomatopora* and *Proboscina*": Geol. Mag., Dec. V, Vol. I (1904), p. 315.
[6] J. W. Gregory: loc. cit., p. 48.
[7] W. D. Lang: loc. cit., pp. 318–322.

It is to facilitate the comprehension of the method of investigation employed that the reader is referred to the paper on "The Jurassic Forms of *Stomatopora* and *Proboscina*."[1] In this paper great prominence was given to the mode of branching; and it was pointed out that the remarkable regularity of this character was peculiar to the Jurassic forms. Three types of branching were described as Type I, the Intermediate type, and Type II; and the order of succession was invariable, the first passing gradually into the second, and the second into the third type. If it may be inferred from the irregularity of the branching in the few Silurian specimens of *Stomatopora* examined that the pre-Jurassic ancestors of the species under consideration were irregular in their mode of branching, the Jurassic regularity appears in the Lower Lias form as a new character superimposed upon a pre-Jurassic irregularity. The apparent expression of this is that although in the Lower Lias form the regular dichotomous branching after Type I, the Intermediate type, and Type II may be observed, it is somewhat obscured by a slight irregularity, and the daughter zoœcia at each dichotomy are of unequal length. Thus a second character becomes involved—the proportion of the length of the zoœcium to the breadth. These points are illustrated in Pl. XIV, Figs. 4 and 5.

Moreover, a slight irregularity occurs in a third character—the shape of the zoœcium. In the Oolitic forms primitive cylindrical zoœcia become pyriform, and in more specialized forms often revert to a cylindrical shape. In *Stomatopora antiqua*, Haime, though the general sequence is cylindrical—very slightly pyriform—cylindrical by far the greater part of the zoarium having cylindrical zoœcia, occasionally a comparatively pyriform zoœcium occurs without any relation to the general sequence in shape. This is well shown in Terquem & Piette's figure of *S. antiqua*, Haime,[2] and in the specimen B.M. D. 7623 (Pl. XIV, Fig. 5). It is true that such sporadic irregularity in any one character is liable to occur to some extent among the most regular Jurassic forms. And the explanation is suggested that so plastic and undifferentiated are these primitive forms that rigid stability of character is not to be expected in the same degree as in the case of the ornamentation of such a highly specialized group as the Ammonites.

Mr. Buckman has offered another explanation of the sporadic appearance of the comparatively pyriform zoœcia. Jackson[3] has shown that in plants a new branch tends to recapitulate former characters more primitive than those peculiar to that part of the plant whence it springs. He applies this to animals as well as to plants, and voices it in the law that "throughout the life of the individual, stages may be found in localised parts, which are similar to stages found in the young, and the equivalents of which are to be sought in the adults of ancestral groups."

[1] W. D. Lang: loc. cit.

[2] O. Terquem et E. Piette, "Le Lias inférieur de l'est de la France": Mém. Soc. Géol. France, ser. II, vol. viii (1868), p. 124, pl. xiv, fig. 32.

[3] R. T. Jackson, "Localised Stages in Development": Mem. Boston Soc. Nat Hist., vol. v, No. 4 (1899), p. 92; see also pp. 139, 141.

Applying this principle, we may say that at every branch in a colonial form such as we are considering there is a potential recapitulation. Now the slight tendency to pyriformation at dichotomies 1 and 2 in the present form shows that the general cylindrical stage was preceded by one which was more or less pyriform. The tendency, then, at each dichotomy is to recapitulate this stage. The potential recapitulation occasionally becomes actual, and appears as the sporadic production of somewhat pyriform zoœcia.

A third explanation of these sporadic zoœcia is that they are simply gonœcia. And the fact that in all organisms reproductive tissue arises from undifferentiated cells may furnish a hint as to why primitive characters are shown in reproductive zoœcia.

Having indicated the directions in which difficulties may be expected in applying the scheme of measurement advanced in the former paper, it is possible to limit Haime's species by the following definition, which takes into account stages of growth :—

I. *Stomatopora antiqua*, Haime. (Pl. XIV, Figs. 2, 4, 5, and 7.)

Characters.—Zoarium loose and spreading, the first dichotomy being after Type I at an angle of about 180°. The Intermediate type of branching appears at the third or fourth dichotomy, and Type II by the fifth or sixth. As has already been remarked, the branching is often somewhat irregular, so that the exact type is hard to determine. There are two peristomes before the first dichotomy, and generally one between the first and second. The acme is reached with three or four peristomes between the third and sixth dichotomies; after which, with a small check at about dichotomy 7, the number of peristomes between each dichotomy rapidly diminishes. The proportion of the length of the zoœcium to the breadth is very variable, but by examination of a number of specimens a general sequence can be recognised. That of the protœcium is about 1, of the second zoœcium about 2. The acme of length is at dichotomies 1 and 2, where it is from 2 to $2\frac{1}{2}$. From dichotomy 2 it gradually diminishes until it is only $1\frac{1}{2}$ at dichotomy 9. The shape of the zoœcia is irregularly cylindrical, with a slight tendency to pyriformation between dichotomies 1 and 2, and with an occasional irregular pyriform zoœcium as already noticed. The ornamentation is a very slight, fairly fine ribbing, but the zoœcia often appear smooth, owing to bad preservation, for which reason it is hard to see any regular change in this character during the growth of the colony. The sides of the zoarium tend to be flattened on to the object which it encrusts.

For comparison the original description by Haime is here given[1] :—

"Les mailles de ce testier ont une tendance à se rapprocher de la forme d'une rhombe irrégularier, et dont les angles seraient émoussés. Les sept premières testules produisent deux bourgeons; il arrive fréquenment que deux testules jumelles soient un peu inégales en grosseur, et restent presque complétement accolées l'une à l'autre;

[1] J. Haime: loc. cit., pp. 162–163.

mais les individus auxquels elles donnent naissance s'écartent notablement l'un de l'autre. Entre une bifurcation et celle qui la suit, on compte ordinairement deux ou trois péristomes en série. La partie rampante des testules est médiocrement allongée, légèrement conique à l'origine, puis cylindroïde et faiblement aplatie ; elle présente des plis fins et d'autres plus prononcés ; les pores sont petits et assez écartés. La grande largeur des testules dépasse un peu $\frac{1}{3}$ de millemétre.

"Ce fossile rappelle tout à fait par son aspect général la *S. dichotoma* ; mais les irrégularités que nous venons d'indiquer dans le mode de multiplication, ainsi que la forme légèrement conique des testules, l'en distinguent suffisamment. Ces testules sont d'un autre côté beaucoup moins longues et moins lisses que dans la *S. Waltoni*.

"Tous les exemplaires que j'ai observés étaient fixés sur Gryphées arquées, et ont été découverts par M. Terquem dans le lias inférieur de Valière (Moselle)."

It will be seen that Haime expressly indicates "les irrégularités dans le mode de multiplication"—the pre-Jurassic trait of this species; also that branching after Type II is exhibited, the "deux testules jumelles . . . . restent presque complétement accolées l'une à l'autre." But the most important fact is not given, namely, the point in the life-history of the colony when Type II makes its appearance.

The folding table (Table I)[1] of observations on nineteen zoaria will give some idea of the limits of variation in this species. The numbers in the first column are those of the dichotomies at which the observation is taken, starting at the proximal end. The columns are headed by the letters B.M. D., followed by two numbers. The letters and the first number stand for the British Museum register number of the specimen, the second number for that of the zoarium on that specimen. In the first eight examples the first dichotomy was seen, so the numbers of the dichotomies are known. In the last eleven, divided from the first eight by a double vertical line, the proximal end of the zoarium was wanting, and so the first dichotomy shown was observed as x, the second as $x + 1$, etc. But by comparison with the first eight, the value of x was surmised. For an explanation of the whole scheme I can only refer to my former paper.[2] The abbreviations used in the table are as follows :—

I, II. = branching after Type I, Type II.
i. = branching after the Intermediate type.
s. = slightly.
v. = very.
180°, 90°, etc. = branches diverging at an angle of 180°, 90°, etc.
cyl. = cylindrical.
pyr. = pyriform.
sm. = smooth.
r. = ribbed.

In Haime's figure the zoœcia are as a whole shorter than in the Tomes specimens, but there is very little difference; and, as has already been shown, partly owing to the irregular branching, the length varies considerably.

[1] Folding Table I to be inserted to face this page.

[2] W. D. Lang: loc. cit.

TABLE OF OBSERVATIONS ON INDIVIDU

Type of Branching.	B.M. D. 7620. 2.	B.M. D. 7620. 3.	B.M. D. 7620. 8.	B.M. D. 7622. 2.	B.M. D. 7622. 3.	B.M. D. 7623. 1.	B.M. D. 7622. 5.	B.M. D. 7623. 2.	B.M. D. 7619. 1.
At dichotomy 1	I. 180°	I. 120°	I. 180°	...	...	I. 180°	I. 180°	I. 180°	...
,, 2	I. 90°	I. ? 90°	...	i. 60°	s.i. 90°	i. 120°	?	i. 120°	...
,, 3	s.i. 60°	s.i. 90°-60°	...	i. 120°	i.-II. 120°	i. 90°	i. 90°	I. 60°-i. 90°	...
,, 4	...	? i. 60°	...	I. 120°-i. 90°	i. 60°-90°	I.-i. 90°-60°	i. 80°	i. 60°	...
,, 5	...	...	...	I. 90°-i. 60°	i.-II. 90°	II. 180°	i. 70°-80°	i. 90°	i.-II. 60°
,, 6	...	...	...	II. 60°-i. 100°	...	II. 90°	i.-II. 60°	...	i.-II. 60°
,, 7	...	...	...	II. 90°	...	i. 120°	II. 45°-60°	...	i.-II. 90°-
,, 8	...	...	...	...	...	...	...	...	II. 45°-60
,, 9	...	...	...	...	...	...	...	...	i.-II. 45°-6
Number of Peristomes.									
Before dichotomy 1	? 2	2	? 2	...	...	? 2	...	2	...
Between dichotomies 1–2	1	? 1	? 1	...	...	1	2	1	...
,, ,, 2–3	1–2	1–2	...	1	1–2	1–2	1	1–2	...
,, ,, 3–4	2 shown	1–3	...	1–2	1	1–3	2	1–3	...
,, ,, 4–5	...	...	...	2–3	3–4	1	1	1	4
,, ,, 5–6	...	...	...	1–2	...	1	1–2	...	2
,, ,, 6–7	...	...	...	2	...	1	1–2	...	1–2
,, ,, 7–8	...	...	...	...	...	...	...	...	2–5
,, ,, 8–9	...	...	...	...	...	...	...	...	1–3
Ratio of Length of Zoœcium to Breadth.									
Zoœcium 1	?	$1\frac{1}{2}$	? 1	...	...	...	...	1	...
,, 2	$2\frac{1}{2}$–3	$2\frac{1}{2}$	2	...	...	? 2	...	$1\frac{1}{2}$	...
At dichotomy 1	$2\frac{1}{2}$–3	$2\frac{1}{2}$–3	2–$2\frac{1}{2}$	...	...	2	$1\frac{1}{2}$–2	2	...
,, 2	$2\frac{1}{2}$–3	$2\frac{1}{2}$–3	...	$1\frac{1}{2}$–2	2	2–4	2	2–$2\frac{1}{2}$	...
,, 3	$2\frac{1}{2}$–4	2–4	...	$1\frac{1}{2}$–2	$1\frac{1}{2}$–2	1–2	2–3	2	...
,, 4	...	2	...	2	$1\frac{1}{2}$–3	2	2–3	2–$2\frac{1}{2}$	...
,, 5	...	...	...	2	$1\frac{1}{2}$–2	2	2–3	2	$1\frac{1}{2}$–2
,, 6	...	...	...	$1\frac{1}{2}$–2	...	2	2–3	...	$1\frac{1}{2}$–2
,, 7	...	...	...	$1\frac{1}{2}$–2	...	2–4	2	...	1–2
,, 8	...	...	...	...	...	...	...	...	1–2
,, 9	...	...	...	...	...	..	...	...	1–2
Shape of Zoœcium.	cyl.	cyl.	cyl. 2nd zoœcium is pyriform	cyl.	cyl. s.pyr. at 2	cyl. or swollen. s.pyr. at 2–3	cyl.	cyl., occasionally s.pyr.	cyl. or swollen
Ornamentation.	sm. v.s.r. at 3	sm. v.s.r. at 3	? sm.	v.s.r.	s.r.	v.s.r.	v.s.r.	v.s.r.	v.s.r.

DUALS OF *STOMATOPORA AQUA*, HAIME.

M. 619.	B.M. D. 7619. 2.	B.M. D. 7620. 4.	B.M. D. 7620. 5.	D.	B.M. D. 7620. 9.	B.M. D. 7621. 1.	B.M. D. 7621. 2.	B.M. D. 7622. 6.	B.M. D. 7624.	B.M. D. 7625.	Average.
.	...	...	I.–s.i. 180°		...	...	...	...	...	...	I. 180°
.	...	...	i.–nearly II.		...	...	...	...	...	..	I.–i. 90°
.	...	...	...	i	i. 60°	...	...	i. 80°	i.–II. 90°	i. 60°	i. 90°
.	i. 60°	s.i. 90°	...	i.–II°	i.–II. 90°	II. 45°	i.–II. 45°	i.–II. 45°–60°	i.–II. 90°	i. 90°	i. 60°–45°
. 60°	i.–II.	i.–II. 60°	...		i.–II. 90°	I.–II. 60°	i. 60°	i.–II. 45°–60°	II. 45°–60°	...	i.–II. 60°
. 60°	i.–II. 60°–45°	...	...		i.–II. 45°–60°	II. 45°	i. 45°	...	...	.	II. 90°–60°
0°–45°	II. 60°	...	...		...	...	...	...	...	...	II. 60°
°–60°	...	...	...		...	...	..	...	...	...	II. 45°–60°
5°–60°	...	...	...		...	...	...	...	...	...	II. 45°–60°
.	...	...	...		...	...	...	...	.	...	2
.	...	...	...		...	...	...	...	...	...	1
.	...	...	1		...	...	...	...	...	3	1–2
.	? 2	...	2 shown		2	3	...	1	3	1–3	1–3
	1	1–2	...		1–2	2–3	3	3	2	3	1–4
	1–2	1–2	...		1–2	2	2–3	...	1–2	...	1–2
2	2	...	...		1–2	...	...	...	...	...	1–2
5	...	...	...		1–2	...	...	...	...	...	2–3
3	...	...	...		...	...	...	...	...	...	2
	...	...	...		...	...	...	...	...	...	1½
	...	...	...		...	...	...	...	...	...	2
	...	...	...		...	...	...	...	...	...	2–2½
	...	...	2–2½		...	...	...	...	...	2	2½
	...	...	2		2	...	...	2	? 2	1½–2	2
2	1½–2	1½	...		2	1½–2	2	2–2½	2–3	2	2½
2	2	2	...		1½–2	2–3	2–2½	2–2½	2–3	...	2
	1½–2	...	...		1½–2	2	2	...	2–3	...	1¾
	1½–2	...	...		...	...	...	...	..	...	2
	...	...	...		...	...	...	...	...	...	1½
	...	...	...		...	...	...	...	...	...	1½
or en	cyl.	cyl. or swollen	cyl., occasionally s.pyr.	cy sw	cyl.	cyl.	cyl.	cyl.	cyl.	cyl.	cyl.
.	v.s.r.	?	s.r.		s.r.	sm. or v.s.r.	sm. or v.s.r.	3–4 s.m. 5 v.s.r.	s r.	sm.	v.s.r.

[**To Binder**!—This Table to be inserted i

W. D. Lang's paper on *Stomatopora antiqua*, Haime: Geol. Mag., June, 1905, to face p. 261.]

mais les individus auxquels elles donnent naissance s'écartent notablement l'un de l'autre. Entre une bifurcation et celle qui la suit, on compte ordinairement deux ou trois péristomes en série. La partie rampante des testules est médiocrement allongée, légèrement conique à l'origine, puis cylindroïde et faiblement aplatie ; elle présente des plis fins et d'autres plus prononcés ; les pores sont petits et assez écartés. La grande largeur des testules dépasse un peu $\frac{1}{3}$ de millemétre.

"Ce fossile rappelle tout à fait par son aspect général la *S. dichotoma* ; mais les irrégularités que nous venons d'indiquer dans le mode de multiplication, ainsi que la forme légèrement conique des testules, l'en distinguent suffisamment. Ces testules sont d'un autre côté beaucoup moins longues et moins lisses que dans la *S. Waltoni*.

"Tous les exemplaires que j'ai observés étaient fixés sur Gryphées arquées, et ont été découverts par M. Terquem dans le lias inférieur de Valière (Moselle)."

It will be seen that Haime expressly indicates "les irrégularités dans le mode de multiplication"—the pre-Jurassic trait of this species; also that branching after Type II is exhibited, the "deux testules jumelles . . . . restent presque complétement accolées l'une à l'autre." But the most important fact is not given, namely, the point in the life-history of the colony when Type II makes its appearance.

The folding table (Table I) [1] of observations on nineteen zoaria will give some idea of the limits of variation in this species. The numbers in the first column are those of the dichotomies at which the observation is taken, starting at the proximal end. The columns are headed by the letters B.M. D., followed by two numbers. The letters and the first number stand for the British Museum register number of the specimen, the second number for that of the zoarium on that specimen. In the first eight examples the first dichotomy was seen, so the numbers of the dichotomies are known. In the last eleven, divided from the first eight by a double vertical line, the proximal end of the zoarium was wanting, and so the first dichotomy shown was observed as x, the second as $x + 1$, etc. But by comparison with the first eight, the value of x was surmised. For an explanation of the whole scheme I can only refer to my former paper.[2] The abbreviations used in the table are as follows :—

I, II. = branching after Type I, Type II.
i. = branching after the Intermediate type.
s. = slightly.
v. = very.
180°, 90°, etc. = branches diverging at an angle of 180°, 90°, etc.
cyl. = cylindrical.
pyr. = pyriform.
sm. = smooth.
r. = ribbed.

In Haime's figure the zoœcia are as a whole shorter than in the Tomes specimens, but there is very little difference; and, as has already been shown, partly owing to the irregular branching, the length varies considerably.

[1] Folding Table I to be inserted to face this page.

[2] W. D. Lang: loc. cit.

Synonymy.—The only figured forms which are likely to be confounded with this species are those described from the Lower Lias of France by Terquem & Piette[1]; and it may be incidentally remarked here that the form mentioned as having been recorded in the Survey memoir is written "*Stomatopora antiqua*, Terquem & Piette." Unfortunately there is some confusion in the French authors' paper. Two forms are recorded—*S. antiqua*, Haime, and *S. Haimei*, Terquem & Piette. The latter species is described and figured. The former is not described, but Haime's description is referred to, and two figures are given on Pl. XIV. The figures to which the direction of the text refers are obviously wrong, being representations of *Neuropora*. However, the legend beneath the plate makes it clear which figures are meant. But the larger of these (the other being a life-size representation of the whole zoarium) is a reproduction, with rather larger peristomes and rather stouter zoœcia, of Haime's figure of *S. antiqua*. It looks, therefore, as if Terquem & Piette had meant the figures they have called *S. antiqua*, Haime, to apply to their new species *Haimei*. As it stands, their *S. Haimei* must become a synonym of *S. antiqua*, Haime, unless or until the form represented by their figure can be proved to differ from Haime's *S. antiqua*. It is a great pity that the name *Haimei* should have to be dropped; for no one who has used this author's beautifully executed plates of these forms could wish otherwise than that his name should be associated with this genus.

The form recorded as *S. antiqua*, Haime, is described below as *S. Gregoryi*, sp. nov.

Horizon and locality.—Haime records the type-specimen from "le lias inférieur de Valière (Moselle)."

The English specimens are from the Sinemurian, mostly from beds which are at the horizon of the zones of *Deroceras armatum*, *Uptonia Jamesoni*, and *Amaltheus ibex*, but the exact zone cannot be determined.

Specimens B.M. D. 7623 and 7624 are from what is probably the zone of *Uptonia Jamesoni*[2] at Aston Magna, north of Moreton-in-the-Marsh, Gloucestershire. From the same locality is a specimen B.M. D. 7622, which is labelled "junction of the Middle and Lower Lias, Aston Magna."

Specimens B.M. D. 7619 and 7620 are from probably the same zone at Fenny Compton, Warwickshire, north of Banbury, Oxfordshire.

The specimen B.M. D. 7625 is from what is probably the zone of *Asteroceras obtusum*[4] at Honeybourne, east of Evesham, Worcestershire.

S. Haimei, Terquem & Piette, is recorded as occurring in "Lumachelle ferrugineuse à *B. acutus* de Chilly, sur une valve de l'*Ostræa chillyensis*." This horizon is Sinemurian.

[1] O. Terquem & E. Piette: loc. cit.
[2] H. B. Woodward: loc. cit., p. 155.
[3] H. B. Woodward: loc. cit., p. 161.
[4] H. B. Woodward: loc. cit., p. 154.

II. *Stomatopora antiqua*, Haime, mutation *capricornensis*.

(Pl. XIV, Figs. 1 and 3.)

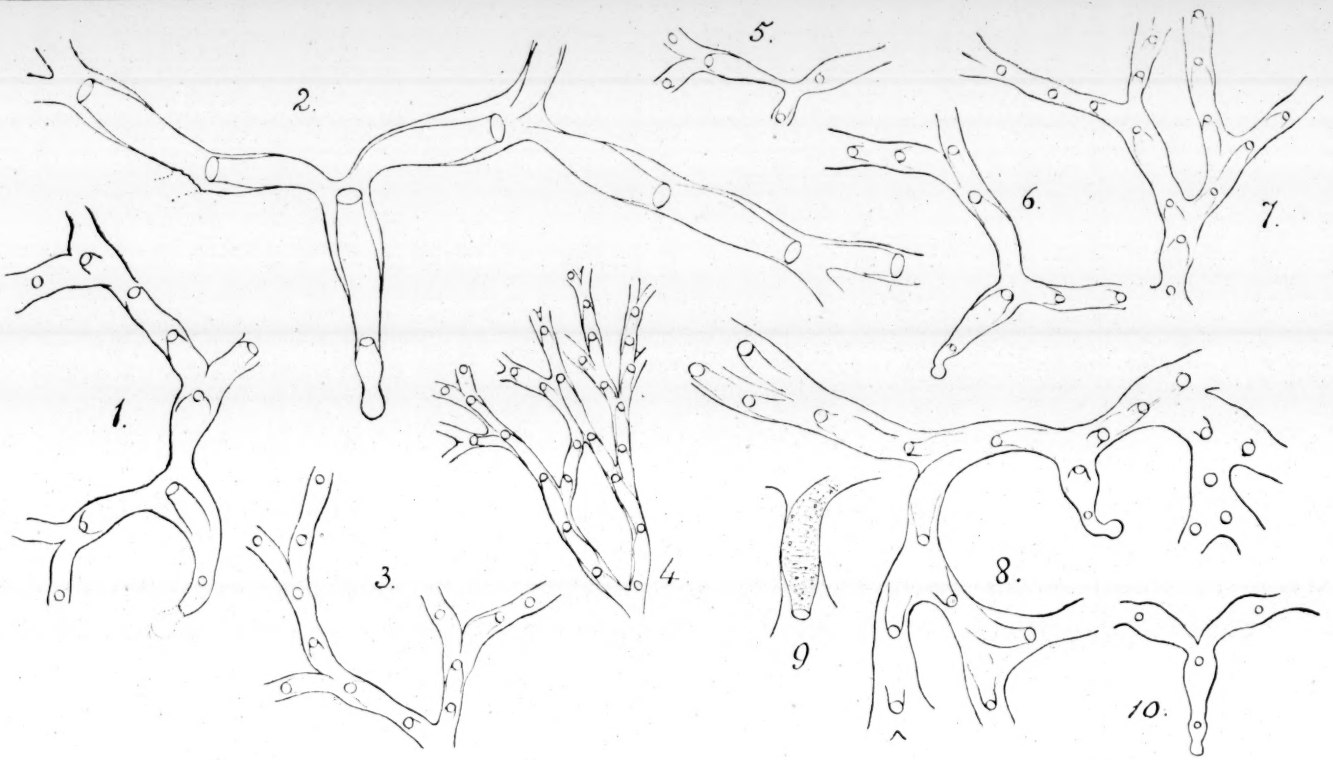
Fragmentary zoaria of a form hardly distinguishable from the Sinemurian species *Stomatopora antiqua*, Haime, occur rather commonly encrusting specimens of the coral *Montlivaltia Victoriæ*, Duncan, from the Middle Lias, zone of *Liparoceras capricornus*[1] at Cherrington, Warwickshire, north-east of Moreton-in-the-Marsh, Gloucestershire. The only apparent difference between this and the Sinemurian form is in that the branching in the former is far more regular, approaching in this respect the Oolitic species. This point is shown in Diagram I, p. 267, where Fig. 3 represents *S. antiqua*, Haime, and Fig. 4 its mutation in the *capricornus* zone. This being the only difference which the fragmentary and ill-preserved material presents, it looks as though this form was a direct modification of *S. antiqua*, Haime, in time; and since no other form has been found at this horizon resembling more closely the Sinemurian species, it may be looked upon as the modification of *S. antiqua*, Haime, in the higher zone. But because this form is not identical with *S. antiqua*, Haime, it is convenient to have a name whereby to distinguish this mutation, as it is called, and I therefore propose to name it *S. antiqua*, Haime, mutation *capricornensis*, indicating in the name the horizon at which the mutation is found.

A table of observations on these fragments is given below.

TABLE OF OBSERVATIONS ON INDIVIDUALS OF *STOMATOPORA ANTIQUA*, HAIME, MUT. *CAPRICORNENSIS*.

	B.M. D. 7539. $x = 1$.	B.M. D. 7470. 2.	B.M. D.7626.	B.M. D.7628.	B.M. D.7629.
Type of Branching.					
At dichotomy x	I. 140°	? i. 45°	II. 100°	I.45°–60°	i. 60°
,, $x+1$ ...	i. 90°	II. < 45°	...	i. 90°	i. 60°
,, $x+2$ ...	I.s.i. 60°–90°	...	...	...	i. 45°
,, $x+3$ ...					
Number of Peristomes. Between dichotomies					
$x-1$ and x ...	2	...	2	...	...
x and $x+1$ ...	1	2	2	2	2
$x+1$ and $x+2$ ...	3	...	...	...	2
Ratio of Length of Zoœcium to Breadth.					
At dichotomy x	$2\frac{1}{2}$	$1\frac{1}{2}$–2	2–$2\frac{1}{2}$	$1\frac{1}{2}$–2	2–$2\frac{1}{2}$
,, $x+1$ ...	2	2	...	...	2–$2\frac{1}{2}$
,, $x+2$ ...	2	...	...	...	2–$2\frac{1}{2}$
,, $x+3$ ...					
Shape of Zoœcium ...	cyl.	cyl.	cyl.	cyl.	cyl.
Ornamentation ...	?	?	?	?	?

[1] H. B. Woodward: loc. cit., p. 157.



To illustrate Mr. W. D. Lang's paper on forms of *Stomatopora* from the Lias of Warwickshire, Worcestershire, and Gloucestershire. (See Explanation of Plate on p. 268.)

III. *Stomatopora Richardsoni*, sp. nov. (Pl. XIV, Figs. 8 and 9.)

A specimen has been found in the Lias of Toddington, north-east of Cheltenham, Gloucestershire, by Mr. L. Richardson, F.G.S., which in its early stages resembles *S. antiqua*, Haime. Branching after Type II occurs as early as the second or third dichotomy, and is general by the fourth, at which point the zoarium has become Proboscinoid. This early branching after Type II is represented in Diagram I, p. 267, Fig. 5, where only the Stomatoporoid stages are shown, and the branching not carried beyond dichotomy 3, in order that an equal comparison may be made with the other forms figured. The irregularity in the branching is retained throughout the Stomatoporoid stages, showing this to be a primitive character directly derived from *S. antiqua*, Haime, and not, as appears to be the case in certain Oolitic forms, a secondary irregularity following normal branching after Type II, and giving rise to such forms as *Proboscina morinica* (Sauvage). The tendency of the sides of the zoarium to become flattened out on the object encrusted so as to form a 'selvage,' as Gregory calls it,[1] is more pronounced than in *S. antiqua*, Haime, and produces in the distal part of the zoarium the type of *Proboscina* resembling the species above mentioned.

The slight pyriformation exhibited by *S. antiqua*, Haime, between dichotomies 1 and 2 is absent. The zoœcia are cylindrical throughout after the first dichotomy.

It will be seen on referring to Pl. XIV, Fig. 8, that after the first dichotomy the right-hand branch is more specialized and becomes Proboscinoid sooner than the left-hand branch. A second zoarium on the same specimen exhibits similar characters to that described and figured, as far as can be seen through the obscuring matrix.

The zone in which this specimen was obtained was probably that of *Uptonia Jamesoni*. At any rate this is the approximate horizon.

Three more zoaria (specimens B.M. D. 7630) on an example of *Montlivaltia Victoriæ*, Duncan, in the collection of the late Mr. R. F. Tomes, from the zone of *Liparoceras capricornus* at Cherrington, Warwickshire, north-east of Moreton-in-the-Marsh, Gloucestershire, resemble the specimen just described sufficiently to be included in this species. An outline figure of one of these specimens is given on Pl. XIV, Fig. 6.

Fig. 6 on Diagram I represents the specimens from the *capricornus* zone, the same form as Fig. 5 being repeated to indicate that that form passes into the higher zone unchanged.

The following is a table of changes in the characters of this species during its life-history:—

Type of Branching.		
At dichotomy 1	...	Type I at 120°.
,, 2	...	Type I–Intermediate type at 90°–100°.
,, 3	...	Intermediate type–Type II at 60°.
,, 4	...	Type II at < 60°.

[1] J. W. Gregory: British Museum Catalogue of Cretaceous Bryozoa, vol. i (1899), p. 150.

Frequency of Branching.

Number of peristomes before dichotomy 1	...	...	2
,, ,, between dichotomies	1 and 2	...	1–2
,, ,, ,, ,,	2 and 3	...	1–2
,, ,, ,, ,,	3 and 4	...	1–2

Ratio of Length of Zoœcium to Breadth, the latter being taken as 1.

Before dichotomy 1	zoœcium 1 ...	...	...	...	...	2
	,, 2 ...	...	...	...	...	$1\frac{1}{2}$
At dichotomy 1	...	...	...	...	...	...	$1\frac{1}{2}$–$2\frac{1}{2}$
,, 2	...	...	...	...	...	...	2–3
,, 3	...	...	...	...	...	...	2–$2\frac{1}{2}$
,, 4	...	...	...	...	...	...	$1\frac{1}{2}$–$2\frac{1}{2}$

Shape of Zoœcium.

Before dichotomy 1 { zoœcium 1, cylindrical.
,, 2, slightly pyriform.

From dichotomy 1 to dichotomy 4, cylindrical.

Ornamentation. Very slightly ribbed.

IV. *Stomatopora Gregoryi*, sp. nov. (Pl. XIV, Fig. 10.)

Mention was made above to the figures given by Terquem & Piette[1] of *Stomatopora antiqua*, Haime. And though only a small part of the zoarium is drawn large enough to clearly show its characters in detail, it appears, by taking what is to be seen in the larger figure with the loose appearance of the branching in the smaller figure, that this form is more primitive than Haime's type, and does not exhibit branching after the intermediate type so soon, if at all, in its life-history.

Moreover, a specimen (B.M. D. 7470, zoarium 1) from the *capricornus* zone of Cherrington, encrusting *Montlivaltia Victoriæ*, Duncan, shows at its first dichotomy a more marked pyriformation than the specimens of *S. antiqua*, mutation *capricornensis*, and resembles more nearly a specimen (B.M. D. 2131) of *S. dichotomoides* (d'Orbigny). Unfortunately more of the former specimen is not preserved, so it is impossible to say whether its further branches showed the characters of *S. dichotomoides* (d'Orbigny). Now the latter species, an Inferior Oolite form, is more simple in its branching than *S. antiqua*, Haime; nor is there anything to show that this simplicity of branching, which even in the distal dichotomies does not proceed beyond Type I, is not primitive. The form, then, must have had a Liassic ancestor with as simple a type of branching. Terquem & Piette's figures of *S. antiqua*, Haime, supplies a possible ancestor. This form, for which I propose the name *S. Gregoryi*, would only differ from *S. dichotomoides* (d'Orbigny) in the pre-Jurassic irregularity of branching and in the lesser pyriformation of the zoœcia. Since the former character was lost and regular branching was acquired during the Pliensbachian time by *S. antiqua*, Haime, it is quite likely that the specimen mentioned above (B.M. D. 7470, zoarium 1) represents the proximal end of a zoarium in this stage, and the form would be known, according to the system advocated, as *S. Gregoryi*, mutation *capricornensis*. The Sinemurian

[1] O. Terquem et E. Piette: loc. cit., pl. xiv, fig. 32.

and the Pliensbachian mutation are represented by Figs. 1 and 2 in Diagram I, on this page.

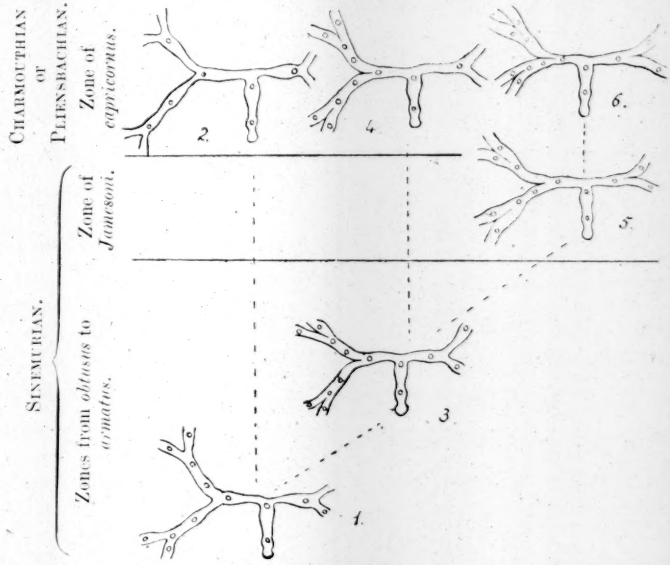


Diagram I.—To show the changes in the method of branching and in the shape of the zoœcium in *Stomatopora antiqua*, Haime, and its related forms.

Fig. 1.—*Stomatopora Gregoryi*, sp. nov.
,, 2.—*Stomatopora Gregoryi*, mut. *capricornensis*.
,, 3.—*Stomatopora antiqua*, Haime.
,, 4.—*Stomatopora antiqua*, Haime, mut. *capricornensis*.
Figs. 5 and 6.—*Stomatopora Richardsoni*, sp. nov.

Note.—A difficulty arises in the system of nomenclature advocated above, wherein the mutation of a species is named as such as if it were a variety; but with this difference, that, while a variety is named arbitrarily, just as a species, the mutation is named according to the horizon at which it occurs. The difficulty is met when the mutations of a given species pass upwards into a form already named. For suppose in the case above it could be demonstrated that *S. Gregoryi* passed upwards through its mutation *capricornensis* and other possible mutations into the Aalenian species *S. dichotomoides* (d'Orbigny), it might be asked, at what point would the one species end and the other begin. A moment's consideration would show that supposing our knowledge of the evolution of a group of organisms were absolute, we should have a number of species in various ramifying series, each merging imperceptibly backwards into its precursor and forwards into its successor. A further examination would show that the forms designated 'species' were groups of individuals taken at arbitrary points in the evolutionary series. For these points would not have been fixed upon according to any predetermined plan, as, for instance, to mark a period of comparative

stability in the evolving form. To have definitely named such evolutionary stations would have implied a complete knowledge of the evolution of the group. But as each point in the series was independently met with, so it was described and named, and its connection with other points discovered later. In the supposed case where this has been done, more than two species would occasionally be found in one unbranched series. It might be said that the names of the middle species, that is, those that lay along one branch between two bifurcations, were useless and might be discarded, or, being only mutations, might be named as such. This, however, would be a pity, for reference marks are needed along an unbroken series. Moreover, since the superfluous names are thus treated as synonyms, the question of priority is at once raised. Therefore it seems advisable in such a case to keep the intermediate names. But where, as in the species described in this paper, slight, hitherto unnamed differences occur as the form passes from zone to zone, the forms could be named as mutations, like those above, in order not unduly to multiply 'species.' The original difficulty, namely, to say where the mutations of one species end and those of another begin, could be solved conventionally by taking the first stratigraphical boundary below the higher species. And if it be objected that such a division is purely conventional, it may be answered that it is chosen no more arbitrarily than is the point in the series from which the individuals comprising a species were taken. With complete knowledge specific boundaries must be conventional. And all the difficulties in nomenclature arise from the inadequacy of the system now in use, which seeks to bind within rigid systematic limits the phases of series which are in a perpetual state of flux.

EXPLANATION OF PLATE XIV, p. 264.

Fig. 1.—D. 7539. *Stomatopora antiqua*, Haime, mut. *capricornensis*, encrusting *Montlivaltia Victoriæ*, Duncan. Middle Lias: zone of *L. capricornus*, ? Cherrington, Warwickshire. × about 12.

,, 2.—D. 7620, zoarium 2. *Stomatopora antiqua*, Haime, encrusting *Gryphæa*. Lower Lias: about *Jamesoni* zone, Fenny Compton, Warwickshire. × about 28.

,, 3.—D. 7629. *Stomatopora antiqua*, Haime, mut. *capricornensis*, encrusting *Montlivaltia Victoriæ*, Duncan. Middle Lias: zone of *L. capricornus*, Cherrington, Warwickshire. × about 9.

,, 4.—D. 7620, zoarium 4. Another zoarium on the same specimen as Fig. 2. × about 8.

,, 5.—D. 7623, zoarium 1. *Stomatopora antiqua*, Haime, encrusting *Gryphæa*. Lower Lias: about *Jamesoni* zone, Aston Magna, Worcestershire. × about 11.

,, 6.—D. 7630, zoarium 2. *Stomatopora* (?) *Richardsoni*, sp. nov., encrusting *Montlivaltia Victoriæ*, Duncan. Middle Lias: zone of *L. capricornus*, Cherrington, Warwickshire. × about 15.

,, 7.—D. 7619, zoarium 1. *Stomatopora antiqua*, Haime, encrusting *Gryphæa*. Lower Lias: about *Jamesoni* zone, Fenny Compton, Warwickshire. × about 8.

,, 8.—*Stomatopora Richardsoni*, sp. nov., on a Brachiopod. Lower Lias: about *Uptonia Jamesoni* zone, Toddington, Gloucestershire. × about 15.

,, 9.—Part of the same specimen as Fig. 8. × about 18.

,, 10.—D. 7470, zoarium 1. *Stomatopora Gregoryi*, n.sp., mut. *capricornensis*, encrusting *Montlivaltia Victoriæ*, Duncan. Middle Lias: zone of *L. capricornus*, Cherrington, Warwickshire. × about 12.

VI.—Old Lamps or New? Another Contribution to Devonshire Controversial Geology.

By Harford J. Lowe, F.G.S.

UNSOLVED geological problems, or what perhaps may be better described as obscure points in geological history round which conflicting hypotheses have arisen, are to be found in many parts of our Islands, but Devonshire seems to be an usually prolific field for them. Mr. W. H. Hudleston, F.R.S., in his presidential address to the Devonshire Association in 1889, enumerates nine questions propounded by Pengelly in 1868 as still requiring special consideration in the future. Of these possibly three may be said to have nearly or quite got beyond the controversial stage, but in the meantime others have arisen, and it would thus appear that the undecided position of numerous points demanding further investigation is the normal condition of a science in the developmental stage.

Evolution involves occasionally the disuse and reversion of organs which formerly were of service, but the more general mode of progress is by strengthening and more highly developing the essential working parts so as to better fulfil their functions in the more complex organism.

Similarly, in the higher development of a science some early working hypotheses must either be abandoned or modified to meet further discovery and more widely extended correlations. The earlier theory, however, is usually tenacious of the hold it has gained by prior possession, and the newcomer must need not only present credentials that will bear the closest scrutiny, but also possess the irresistible power of simplicity and superior fitness in order to gain the position it lays claim to.

Now there is a time-honoured and simple theory respecting the origin and formation of some peculiar deposits within the basin of the River Teign, whose right to possession of that small holding has been called in question by several statements to be found scattered among the geological records. No direct attempt has been made to oust the old tenant and place another with a better title in its place, but its position has been discredited by casual remarks and innuendo, and its existence has been ignored when its territory has been invaded by the explorer.

We learn from one of our early masters, who is also regarded as one of the keenest and most reliable of observers, De la Beche, that within an area roughly defined as from a little south of Newton Abbot to a little north and east of Bovey Tracey lie deposits of lacustrine origin which now form a tract of level land traversed by the streams Teign and Bovey, which presumably brought down the material now filling up the lake depression formerly occupying this part of their courses. In the master's own words—"From the manner in which the Bovey deposit conforms to the valleys adjoining it, the character of the clays and sands, and the greater purity of the clays towards Kingsteignton and away from the granite

of Dartmoor, we may be led to infer that prior to the production of the Bovey beds a depression was formed in this locality subsequently to the destruction of the mass of chalk and a considerable portion of the greensand which there once existed, and that the materials for this deposit were chiefly derived from decomposed parts of the adjoining granite gradually carried down by streams, the quartzose parts forming the sands, the decomposed felspar borne onward to where it could quietly settle and form the clay."[1]

That is the simple explanation given in 1839 to account for the peculiar clay, sand, and lignite beds of the Bovey area, and it has been confirmed and strengthened by other geologists, particularly Pengelly, who investigated the formation fully and from whose palæontological discoveries therein Professor Heer arrived at the conclusion that the beds were of Miocene age. In most of the students' manuals upon British geology this explanation of the origin and position of these beds is given, and it still holds the field, for in the latest edition (1903) of Professor Archibald Geikie's Text Book of Geology we find them referred to as "a small but interesting group of sand, clay, and lignite beds, from 200 to 300 feet thick, which lies between the granite of Dartmoor and the greensand, in what was evidently the hollow of a lake." The lake hypothesis might thus be called the orthodox view, since other suggestions antagonistic thereto have not so far been able to command general attention, much less acceptance. That being the case it might be thought that little service would be rendered by dragging immature views before the public notice; but the matter has become more involved since the new Geological Survey map of the district in question has been published, inasmuch as the gravels which cap the bordering hills are now coloured the same as the Bovey lake area, thus associating the two as members of the same series which were disassociated by colour and name in the old maps.

An attempt to trace the steps which have led to this change and to examine the data upon which a new theory is being constructed, may be of interest.

The following citations are from papers by Mr. J. Starkie Gardner:—"The fossil plant remains met with in the Bournemouth beds, especially those in the marine series, are so strikingly similar to the Bovey Tracey fossils, as to make it clear to my mind that the latter have been wrongly assigned to the Miocene. I believe, in fact, that they are simply an outlier of the Bournemouth series, from which they are but eighty miles distant."[2]

"Time has, however, completely refuted upon plant evidence the theory that the Bovey beds are Miocene, and unmistakably identified them with the Middle Bagshot of Bournemouth. Upon geological evidence also the improbability is apparent of such great deposits being accumulated in a Devonshire valley without any trace of them existing elsewhere, and a theory which brings them into a defined

[1] De la Beche: Geol. Report of Cornwall, Devon, and Somerset, p. 257.
[2] Quart. Journ. Geol. Soc., 1879, vol. xxxv, p. 227.

position in the consecutive formation of the country would be a welcome one." [1]

These Bovey beds being contemporaneous with the Eocene at Bournemouth, "we see that this silted up lake lies in the direction whence the great Eocene river came, and must either have been in its direct course or in that of one of its affluents." [2]

The Eocene river (Hampshire basin) "must have been more than a mile in width, and the width of its valley subject to floods cannot have been less than 9 miles, and was possibly even 16 miles. The total absence of boulders and the fineness of the silt show that it flowed over a comparatively flat area, and the absence of lignite throughout a great part of its thickness that probably there were lakes or catchment basins in its course to intercept drifting timber. Possibly the Bovey Tracey lignite beds, only 80 miles distant, which are undoubtedly about the same age, may be relics of these. The complete absence of any material derived from flint or chalk shows that no chalk ranges were cut through by it, and the quartzose and granitic sand and pipeclay that its sediment must have been mainly derived from an old rock area." [3]

The following are taken from papers by Mr. Clement Reid:—

"A study of the composition of the Eocene gravels shows distinctly that the rivers that brought them must have flowed from the west or south-west." [4]

"The lower Bagshot sands become coarser and more purely fluviatile westward." [5]

"It is noteworthy that the new evidence discovered in the western end of the Hampshire basin strongly supports the idea that the pipeclays of the Bagshot series are derived from the weathering of the Dartmoor granite, and that the Bovey Tracey outlier so like the deposits around Bournemouth is, as maintained by Mr. Starkie Gardner, of the same age, and deposited in the same basin, though in Devon Eocene rest directly on Palæozoic rocks." [6]

"The general conclusions arrived at from my recent work in Devon and Dorset are therefore:—1st, that the supposed litoral Cretaceous rocks near Dartmoor are Eocene, and that no trace of Cretaceous shore-line is there visible. 2nd, that, as has been for some time maintained, the Bovey beds are Eocene, not Miocene. 3rd, that the high-level plateau gravels of Haldon, like those of Blackdown in Dorset and probably those of the Cretaceous hills between the two districts, are of Lower Bagshot date and mark the course of the old Eocene river." [7]

Ignoring apparent discrepancies in an attempt to connect and summarise the general purport of these extracts, we first note that they sweep away our formerly supposed geological representative of

[1] Geol. Mag., 1879, New Series, Decade II, Vol. VI, p. 152.
[2] Ibid., p. 153.
[3] Quart. Journ. Geol. Soc., 1882, vol. xxxviii, p. 10.
[4] Quart. Journ. Geol. Soc., 1896, vol. lii, p. 492.
[5] Ibid., p. 490.
[6] Ibid., p. 494.
[7] Ibid., 1898, vol. liv, p. 236.

Miocene times. Instead of considering the Bovey beds as a unique deposit within our boundaries, we are hereby directed to regard them as only a small portion of once widely extending beds that is saved from the destruction of denudation that most of the formation has met with, by sinking into the hollow in which they are now found. We also learn from these extracts that the gravels and sands which are found capping the hills bordering the Bovey area are really stratigraphically below and form the basal portion of these deposits, the whole series being of Middle Eocene age. We are to consider them further as western portions of and once continuous with the Lower and Middle Bagshot beds of Hampshire, of fresh-water origin, the detrital material of an Eocene river which flowed from the west.

The following examination of some portions of this theory applies generally to the deposits in question that are to be found in the neighbourhood of Bovey, and is an attempt to ascertain whether this view, as compared with the older theory, more satisfactorily interprets the geological facts within this area, when the natural inferential and collateral questions arising from it are considered.

And first in respect to the river. Presumably as the gravels, sands, and arenaceous clays which form the lower member of this series are to be regarded as river drift, we must infer that the removal of all the chalk and a portion of the greensand that once covered the area now overlain by these gravels was also the work of this river. If so, there must have been no inconsiderable thickness of chalk lying over the Haldon area destroyed by this river, not in the usual way of cutting through it, but by sweeping the whole area of the Cretaceous deposits, entirely in some parts, and down to a portion of the Greensand in others. Accompanying this destruction was the conveying from higher elevations westward of similar material to that removed, and its distribution over the area thus eroded, i.e., the deposition of the gravels, etc., now termed Lower Bagshot beds. The coarseness of much of the material of these beds demands the assumption of a rapid current and consequently a comparatively high angle of elevation to the land westward. The size of the river is another point of remark, since its width within the district indicated as measured by the extent of these gravels, taken either north and south or east and west, must have been at least 12 miles. The present boundaries have, of course, been much narrowed, yet further east similar criteria must give even greater width. Now the length of the river could not be in proportion to the width, even though this portion might be considered a part of its estuary (which the coarseness of the detritus would scarcely warrant), for it is supposed to flow from the west or south-west. From Mr. W. H. Hudleston's address[1] before referred to it appears that only 200 miles west of South Devon the edge of the deep basin of the Atlantic is met with, the limit of the European land area in that direction and the boundary of a geologically permanent drainage

[1] Trans. Devon. Assoc., 1889, p. 33.

area. Now supposing that the Eocene land stretched to the utmost boundary westward, and that its slope was eastward from almost its western limits, probability must be further strained to assume such a large river within so narrow a strip of land.

What is more remarkable, however, is that, although so large and swift a stream, it brought down no foreign material whatever, for these gravels contain only chalk and greensand débris with some other fragments of rocks that are to be found in their immediate neighbourhood. This negative evidence must surely be of fatal import, since even though the chalk area stretched further westward than Devonshire, still it would hardly be considered possible that the whole course of the river was during its term of existence only over and through the same Chalk formation.

These gravels are assigned to the Bagshot age of the Eocene era, which means a lapse of time subsequent to the close of the Cretaceous period, during which the new Tertiary land subsided eastward, allowing the formation of the lower Eocene members, viz., the Thanet beds, the Reading beds, and the London Clay, totalling some 500 feet of new deposits, before the gravels in question are supposed to be formed from the long upraised chalk land. Now although this geological hiatus within this area must be inferred in order that the Eocene era might half spend itself before the appearance of the river to form these gravels, yet strangely and unfortunately no distinctive forms of Eocene life are found among its fossils; indeed, only such palæontological evidence is met with in them as to declare them to be simply chalk and greensand débris. May not this be taken as an indication of earlier formation than that assigned?—a supposition in keeping with the observation that the material of the deposits and conditions of formation were unsuitable for gathering and preserving contemporary biological evidence.

Now these difficulties which seem to naturally arise with the assumption that the gravels are river-borne do not present themselves when the older theory referred to by Mr. Reid (*ante*, p. 271) by the words "litoral Cretaceous rocks" are considered. De la Beche thus accounts for them:—"From the unrolled condition of a large proportion of the flints in the neighbourhood of Lyme Regis, Sidmouth, Chard, and Blackdowns, we are led to suppose that the chalk in which they were embedded may have been quietly removed from among them, and that these flints may have been let down nearly in places above which they occurred in the chalk."[1] Quoting again from Mr. W. H. Hudleston's address:—"Speaking of the geology of the neighbourhood of Dawlish, Mr. Ussher says there can be little doubt that the Cretaceous highlands of Devon, such as the Haldons, are portions of a great plain of marine denudation, and he speaks of a time when that Cretaceous tableland abutted on the flanks of Dartmoor."[2]

The facts, then, pertaining to the gravels of the area in question can be accounted for, without involving inferential difficulties, by

[1] Op. cit., p. 255.
[2] Trans. Devon. Assoc., 1889, p. 32.

assuming that they are of shallow sea and shore formation; that the western border of the chalk and greensand deposits becoming exposed to tide, wave, and current action, was thoroughly disturbed by these agencies, that the beds were worn down, sifted, and the materials rearranged; and that while subjected to these processes some new material was being added from the shores and streams of the bordering Dartmoor land in relative proportion to the distance from that shore.

Turning now to consider the plastic clay, sand, and lignite beds which overlie a part of these gravels and form such a distinguishing feature in the geology of the Bovey area, the first question that presents itself in regard to them is, what relation, in time, do they bear to the beds immediately preceding them in position? Were these deposits laid upon the gravels without any material break in time, alteration of conditions, or change of agency? The citations are not definite upon these points, but as each writer attributes the gravels and clays respectively to the agency of an eastward-flowing Eocene river it would appear as though the later author had adopted the river of the former, thus making the formations consecutive in both position and time. In respect to the latter point there does seem to be some doubt in the mind of Mr. Reid as to the exact horizon of the clays in the Eocene series, for he writes:—"With regard to the age of the lignite and pipeclay of Bovey it is difficult yet to speak with confidence. Mr. Starkie Gardner has pointed out that the flora is probably of Bagshot age, not Miocene as stated by Heer, and the resemblance of the deposits and of their flora to the undoubted Bagshot of Dorset is most striking. Still, one cannot say that the botanical evidence is conclusive, for the species are few and greatly need re-examination."[1]

Now the gravels and clays bear no relation to each other in either mineral constitution or origin, so that there does not appear any acceptable way of reconciling these facts with the hypothesis that the same river was responsible for both deposits.

The supposition is rendered more untenable by the statement on p. 271, *ante*, that "the complete absence of any material derived from flint or chalk shows that no chalk ranges were cut through by it, and the quartzose and granitic sand and pipeclays that its sediment must have been mainly derived from an old rock area." This provokes the query, how could that river flow from the west in Middle Eocene times without going over and through Cretaceous deposits?

But it is the exact mode of deposition of the Bovey clays, sands, and lignites only that we are now considering; their origin is so evident as to be beyond dispute. The authors cited declare that these beds do not form an independent deposit, but an outlier of Eocene strata that formerly extended from Mid Devon to the Isle of Wight. It should perhaps be noticed that Mr. Gardner does not appear to be quite convinced as to the exact relation of the deposits

[1] Quart. Journ. Geol. Soc., 1898, p. 236.

to their original basin. In quotation *ante*, p. 270, he thinks the lake theory unsatisfactory; in the next extract he seems to accept that theory. In another, p. 271, he considers the clays might have been formed in lakes or catchment basins in the course of the Eocene river; but Mr. Reid writes with conviction that the Bovey beds are simply an outlier as expressed by Mr. Gardner in citation on p. 271.

Now the assumption that the beds were formed in a lake by an affluent of the Eocene river does not disturb the old theory at all, and in consequence needs no comment. That the lake might have been one in the course of the main stream would raise the question, how are the clays further eastward to be accounted for if the river was cleared of its detrital material by the Bovey lake?

The consideration of the Bovey area as a 'catchment' basin would imply that close under the slopes of Dartmoor low-lying land 9 by 4 miles in dimensions received a part only of the water and detritus of a river flowing eastward along its southern border. That in this way from 300 to 400 feet of deposits were formed without the help of streams from land bordering it on the north; for although the Dartmoor granite is the undoubted origin of the clay and sand material of these deposits, yet streams coming directly into the area therefrom are precluded by the terms of the hypothesis. Now streams have flowed down that slope of Dartmoor continuously since even pre-Eocene times, so that the 'catchment' supposition can hardly be maintained in the case.

It is, however, the 'outlier' view that demands the closest consideration. This implies that the deposits were spread more or less regularly over the area before indicated, extending some 100 miles east and west. Data are wanting to get an estimate of the width of the supposed basin, but if the gravels may be used as such it might be taken to be from 12 to 25 miles westward, and about 25 miles wide towards its eastern limits. This hypothetical 'lagoon' during the deposition within it of the Middle Eocene fresh-water beds received apparently very little else than the detrital material of Dartmoor, from which the clays and accompanying sands were derived. Now, however, we may regard the distribution of these beds over this area; from the figures available respecting the present existing remnants! the supposition that they were continuous implies such an enormous amount of derived material as to seem incompatible with the reputed source of supply. Mr. Gardner accepts Pengelly's estimate of the Bovey clays as "440 feet without bottom being reached," and his own estimate of the fresh-water series of Bournemouth is from 600 to 700 feet thick. Regarding these deposits, 80 miles apart, as continuous in the light of the remarks that they "have been mainly derived from an old rock area," and "are derived from the weathering of the Dartmoor granite" (*vide ante*), we are impressed with the enormous demand made upon that comparatively small granite mass. Put into terms of roughly comparable measurement, it may be represented thus:—A part only of an area of less than 250 square miles called upon to supply material hundreds of feet in thickness over more than 1,500

square miles of surface within the narrow limits of one unit of geologic time. Does not the supposition provoke the question of possibility in place of probability?

Another consideration suggested by the 'lagoon' hypothesis is the remarkable thickness of the clay beds on the western side so near the source of origin. The material of the clay derived from the decomposition of the felspars of the granite is of extreme fineness, probably the most impalpable material forming deposits, so that it would be held in suspension longer than any other detrital material, and would be precipitated only where the water was almost, if not quite, motionless.

Consequently it does not seem to be consistent with the nature of the material in suspension that such an enormous deposit should have been made close to the foot of the steep slopes of the granite, where the rapid streams bearing the detritus would cause continual commotion and currents that would make themselves felt for considerable distances in a large tideless water area; so that the deposition of the finest material would hardly take place quite near to the stream discharges without some check to the motion of the water such as narrower land boundaries would give. One would therefore expect to find the finest and purest clay in thickest beds away from that part of the 'lagoon' where the streams entered it, while the coarser material would indicate that locality. The sands could scarcely reach the farther part of the basin until the western part was shallow enough to allow the streams to retain sufficient carrying power to convey them. But this arrangement is not found in the fresh-water deposits of the Hampshire basin, and indeed Mr. Gardner accounts for the way they occur rather by current action in an estuary than by deposition in an entirely water-covered area. The same line of thought occurs in connection with the 31 superimposed lignite beds found so near the discharging place of the streams. If there had been a much larger sheet of water than the Bovey area comprises, would it not be likely that the drift vegetation forming the lignite beds would have floated farther away before becoming waterlogged and settling down with the fine clay material?

In respect to the point whether the waters of Dartmoor did convey the Eocene deposits to the Hampshire basin there seems to be an almost absolute criterion, for any sands so carried would certainly contain a considerable proportion of tourmaline or schorl grains such as are to be met with in the sands at all levels within the Bovey area that are associated with the clays. There is no mention of such mineral in the detailed descriptions of the Eocene sands of Hampshire, which may be an oversight, but if not, the absence of the mineral must surely necessitate a reconsideration, if not of the origin of the clay, at least of how the clay became disassociated from its native matrix material, to be found in company with other siliceous deposits.

These considerations arising from the references made to the Bovey clays seem to me to militate against the 'outlier' theory in respect to these deposits, while no such difficulties present themselves in

connection with the older and simpler lake hypothesis. Having elsewhere reviewed the geology of the Teign basin upon the basis of the lake theory,[1] my attention was called to views which had been more recently propounded in respect to the clays and gravels. In subjecting these to examination I have endeavoured to do so with scientific spirit and method, for having so far interested myself in the problems I desire to find a rational interpretation of the geology of a neighbourhood which is very familiar to me.

REVIEWS.

I.—Ice or Water. Another Appeal to Induction from the Scholastic Methods of Modern Geology. By Sir Henry H. Howorth. K.C.I.E., D.C.L., F.R.S. In three volumes. Vols. i and ii. (Longmans, 1905.)

TO some books justice can be done in a short notice, but hardly to such a one as this. Reviewing "Ice or Water" in the pages of the Geological Magazine is something like condensing an ox into a teacup, once depicted in an advertisement. Besides that—though this reduces the quantity of material—the work is not yet complete. We have only the first and second of three volumes, and may thus misunderstand their author, as we lack his final summing up. Here, however, we are probably saved from any grave error by a lucid and rather lengthy preface, and by being told that the book is virtually a continuation of those learned works with which we are all familiar—"The Mammoth and the Flood" and "The Glacial Nightmare." It may therefore suffice to state, as shortly as possible, the contents of these two volumes, adding, as the book is entitled an appeal to induction, one or two comments on the author's use of this method of reasoning.

In "The Mammoth and the Flood" Sir H. Howorth, as he tells us, explains certain well-known phenomena by "a cataclysm on a widespread scale, which caused very important dislocations of the earth's surface, accompanied by gigantic tidal waves" (would not the dislocations cause the cataclysm, if that word be used in the ordinary sense?); and in "The Glacial Nightmare" he prefers it, after a critical discussion, to the invocation of a Great Ice Age as an explanation of the "last touches and alterations made in the configuration of a large part of the earth's surface and of the soft deposits which cover it."

The opening chapters of the present work are devoted to a critical examination of the Astronomical and Meteorological Theories of an Ice Age; from which both, and especially the former, emerge in a dishevelled condition. The author next dismisses as unsatisfactory other explanations, some of them only modifications of Croll's, till the stage, as at the end of "Hamlet," is strewn with the

[1] Trans. Devon. Assoc., 1903, pp. 631–645.

slain, and he clears away the corpses by declaring all known glacial theories to be inadequate. After this slaughter grim and great, he turns aside to discuss air, wind, and water, rain, rivers, and sea, as agents of denudation or deposition, afterwards subjecting ice to a very rigid cross-examination as to its boasted powers as an eroder and excavator. He then tells us what subterranean forces can do as fashioners of the earth's surface, informing us by the way that corries and cirques are due to subterranean movements no less than the breached craters of Auvergne and even the complete one of Cotopaxi (vol. i, p. 535). In the second volume he brings forward "some *à priori* arguments against the Great Ice Age," which, however, prove to be mainly discussions of the supposed evidence of ice-action in the Permian breccias of the Midlands, the Gondwana Series of India, and similar deposits in Australia, Tasmania, and South Africa. None of these, he maintains, allows us to think that the "Ice King ever took such a liberty as to put his arms round the waist of our mother earth." If, then, we cannot attribute the transport of these blocks to ice, we are driven to seek some other cause. He next examines the biological evidence for the so-called Ice Age and the Interglacial Periods, besides that for the alleged southern frontier of the Drift beds and their rock materials, and maintains these materials to be derivative, which, in a certain sense, is indisputable. Next he discusses the bearing of the external features of the Drift on the theory of an Ice Age, and concludes the volume with a description of the Arctic regions in Glacial times, maintaining the ice in these to be now about at its maximum.

The present work has all the characteristics of its predecessors. No pains have been spared in searching the literature of the subject. Whether we accept the author's conclusions or not, we owe him a debt of gratitude for bringing together in a readily accessible form such a mass of information; though, as the work may remain for some time incomplete, we should have been grateful had each volume been provided with an index, or at least with a much fuller table of contents. The author also would have done well had he prevailed on some geological friend to read over his proofs, for typographical errors, notwithstanding a considerable table of errata, are still rather too numerous. These trifling blemishes, however, cannot detract from the value of "Ice or Water" as a book of reference. But, great as this undoubtedly is, the work, we think, has the defects of its qualities. Though professing to be an appeal to induction, its methods are forensic rather than strictly scientific. Advocates and philosophers alike often reason inductively, but with this difference: the one selects and groups his facts so as to sustain his case; the other, after placing all, so far as he can, in right perspective, draws from them the inferences which seem the most accordant. At least, this is the true inductive method, though we cannot say that it is always followed by enthusiastic glacialists, whom we gladly leave to the author's tender mercies. Again, his method of conducting his case occasionally reminds one of that eminent advocate who, some sixty years ago, won the sobriquet of

'Apple-pip.' This may serve as an example. Stones in boulder-clays are frequently striated, and most geologists now accept those marks as indicating the action of ice. This interpretation he disputes, proposing, as we think, improbable alternatives. Excellent authorities declare that striation may be produced by the friction of stones one against another when embedded in a rock-mass; they may be of the nature of slickensides. That is undoubtedly true, but stones thus marked are not common, and only occur under special circumstances. He tells us they may be scratched accidentally by the passage of a plough or harrow, and, as he might have said, by boys using them as substitutes for a toboggan; these, again, are local in occurrence and can usually be distinguished. They may be scratched by mutual friction when swept along by a rapid stream. That also is true, but anyone who has examined the pebbles in a torrent bed or on the sea-shore knows that such markings are few and far between. Sir H. Howorth practically ignores two other facts: the abundance of these striated pebbles in many British boulder-clays, and their occurrence in the till of the Swiss lowland, from which we can track them up to the existing glaciers, while he lays stress upon the fact that they are rare in moraines connected with such glaciers. Naturally they are, because at the present day most of the morainic material has travelled on, not under, the ice, but they may be found if we hunt for them in the right place.

His method of citing authorities is also, we think, distinctly forensic. Science is progressive, so that, though the facts recorded by a careful observer may hold good for all time, his interpretation of them may prove to be erroneous. But if one of "his masters," say Murchison, whom he seems to hold in special veneration, has referred some phenomenon to diluvial or other form of catastrophic action, he is perfectly content; forgetting that the efforts of ice were practically unrecognised in Britain sixty years ago. The same uncritical use of quotations has led him to give renewed currency to Buckland's mistaken reference of the quartzite pebbles, so abundant in the Bunter beds of the Midlands, to the Lickey Hills. But adverse authorities meet with much less reverential treatment. If Colonel Feilden states that a stone in an Arctic deposit is ice-scratched, that is followed by "(say scratched, H. H. H.)." Considering that the former's experience in the field has been so much the greater, to treat his writing as a schoolmaster does a boy's exercise is a rather strong measure.

But though the author too often reminds us of a skilled cross-examining counsel, we gladly admit that some of the extremists in glacial matters leave the witness-box in a very damaged condition. He has a most uncomfortable habit of taking up a bunch of puppet hypotheses and, as it were, knocking their heads together. But he succeeds better as a destroyer than a constructor. He takes away an ice-sheet to put a deluge in its place. But we are entitled to ask for some proof that the substitute could produce such deposits as the drifts of the Norfolk coast or transport such boulders as it contains. For a deluge to lay down a rather large group of stratified sands

and clays is no easy feat, and for it to transport masses of chalk several thousand cubic feet in volume, perhaps for some miles, would be yet more difficult. It is not explained by quoting cases of the effect of waves in violent storms or of what a rush of water has done when pent up in a narrow valley. The great chalk and other limestone erratics of the more eastern part of England, the smaller but still very considerable boulders of the more western and central districts, have often been moved over a comparatively open district, where the mightiest rush of water would quickly lose its force, or have been transported across the general trend of the valleys. So, though, as we have already said, Sir H. H. Howorth deserves the gratitude of every student for these full storehouses of glacial literature, we think that (to reverse the old saying) in seeking to avoid Scylla he has been swept away by Charybdis. T. G. B.

II.—Memoirs of the Geological Survey of England and Wales.

The Geology of the North Staffordshire Coalfields. By Walcot Gibson, B.Sc., F.G.S.; with contributions by George Barrow, F.G.S., C. B. Wedd, B.A., F.G.S., together with a Palæontological Account and List of Fossils by J. Ward, F.G.S. pp. vii and 523, with 8 plates and 21 illustrations in the text. (London: printed for His Majesty's Stationery Office; sold by E. Stanford. Price 6*s*.)

THIS memoir contains a detailed account of the Coalfields of North Staffordshire, especially those of the Pottery and Cheadle Coalfields.

The Palæontology of the Pottery Coalfield is described in detail by Mr. John Ward, and is accompanied by full lists of the fossils. Details of numerous pits and quarries are given in an appendix, also a complete bibliography. There are numerous illustrations, including a colour-printed map of the Cheadle Coalfield on a scale of one inch to a mile, and six plates of the principal fossils of the Coal-measures.

The Triassic and Glacial deposits are described in separate chapters. The economic products of the Pottery Coalfield are described in chapter xii. The account includes the question of the future coal-supply of the district, in addition to a description of the local building-stones, clays, and marls, supplemented by an enumeration of the chief sources of water supply.

The original Geological Survey was made on the Old Series one inch map, Sheets 72 N.W., 73 N.E., and 81 S.W., published during the years 1852–1864, the Coal-measures having been mapped by Sir W. W. Smyth, Permian and Trias by Professor E. Hull, and the subdivisions of the 'Yoredale Rocks' and Millstone Grit by Professor A. H. Green. The memoir on the Iron Ores of North Staffordshire, by Sir W. W. Smyth, published in 1862, contains a summary of the geological features of the coalfields; and brief accounts of the northern end of the Pottery Coalfield, known as

the Biddulph Trough, were published in 1866 in the memoir on the Geology of Stockport, Macclesfield, Congleton, and Leek, by Professor Hull and Professor Green.

The re-survey on the six inch scale was commenced in 1898 and completed in 1901. The Pottery Coalfield was surveyed by Messrs. W. Gibson and C. B. Wedd, and the Cheadle Coalfield by Mr. George Barrow.[1] The area is included in the New Series one inch Sheets 110, 123, 124. Drift and Solid Editions of Sheet 123, with an explanatory memoir, were published in 1902. A description of the Cheadle Coalfield, with an accompanying geological map (part of Sheet 124), was published in 1903.[1] A sheet of Vertical Sections, giving sections of shafts in the Pottery Coalfield, was published in 1901. Sheet 110, which includes a small portion of the Pottery Coalfield, has been prepared for publication; while thirty-five quarter-sheets on the six inch scale, including the whole of the ground described in this memoir, were published with geological lines in 1904.

Although this volume contains the detailed descriptions by each geologist of the area surveyed by himself, it has been largely written and edited by Mr. Walcot Gibson, who personally carried out the greater part of the field-work. In the Palæontological portion, the Survey fortunately obtained the assistance of Mr. John Ward, of Longton, whose knowledge of the district extends over nearly fifty years. Mr. Ward has now contributed copious lists of fossils, together with a palæontological statement in reference to them, the result of his long-continued researches in the North Stafford Coalfields. In the preparation of these lists Mr. Ward has been greatly indebted to Dr. R. H. Traquair, F.R.S., and Dr. A. Smith Woodward, F.R.S., for recording the Fossil Fishes; to Mr. R. Kidston, F.R.S., for the Plants; and to Dr. Wheelton Hind for cataloguing the Lamellibranchs, and in the preparation of the lists of Invertebrata generally. Mr. J. T. Stobbs and many other local geologists have given much assistance to the re-survey of the Coal-measures, and added greatly to the value of the present memoir.

Four of the plates, accompanying the lists of fossils, illustrate the Fishes of the Staffordshire Coalfield, and two are devoted to the Lamellibranchia described by Dr. Wheelton Hind in the Palæontographical Society's volumes.

In the account of the Carboniferous rocks it has been found advisable to adopt purely descriptive terms for the various subdivisions. Though, as is well known, the vertical distribution of both plants and fishes points to a twofold division of the Carboniferous rocks, the exact position and nature of the boundary-line has not yet been determined for North Staffordshire. For the old term 'Yoredale Beds' the term 'Pendleside Series,' introduced by Dr. Wheelton Hind and Mr. J. Allen Howe, seems preferable, since it only implies a correlation with similar beds occupying the same stratigraphical position on Pendle Hill in Lancashire.

[1] Reviewed in GEOL. MAG. for 1903, pp. 471, 473.

For similar reasons the terms Upper, Middle, and Lower Coal-measures have not been adopted; since the positions of the palæontological boundary lines or zones, which may give a definite significance to the terms, have not been determined with accuracy.

It is evident, as pointed out by Jukes long ago, that as regards the higher portions of the Coal-measures, North Staffordshire presents the type-development for the Midlands. In that region Mr. Gibson has established a definite stratigraphical sequence in the comparatively barren strata which conformably overlie the productive Coal-measures, and he has also proved that the same sequence may be recognised in the other coalfields of the Midland area.

The points of special economic interest are given in a separate chapter, considerable attention being paid to the future development of the coalfield.

The portion of the memoir descriptive of the Cheadle Coalfield is largely a reprint from a separately published memoir on this small coalfield by Mr. G. Barrow.[1] Since the publication of that memoir the prediction there made that the Dilhorne Coal underlay the Delphouse area has been verified by actual sinking.

The formations and groups of rock in North Staffordshire are arranged in the following descending order of sequence, the sedimentary and igneous rocks being kept distinct:—

TABLE OF FORMATIONS.

Sedimentary.

Pleistocene and Recent	Recent and Post-Glacial		Alluvium, peat, and river gravels.
	Glacial		Clays, sands, gravels, and erratic blocks.
Trias	Keuper		Marl, soft flags, and building-stones.
	Bunter		Sandstones and conglomerates.
Carboniferous. Coal-Measures.	The Red and Grey Series	Red sandstones and marls (Keele group).	
		Grey sandstones and marls (Newcastle-under-Lyme group).	
		Red marls and green grits (Etruria marl group).	
		Grey shales and marls, thin coals, and bands of Blackband ironstone (Blackband group).	
	The Grey or chief Coal-bearing Series	Grey shales, sandstones, and marls, with numerous seams of coal and clay ironstones in upper portion.	
	Millstone Grit		Grits and shale.
	Pendleside Series		Grits, crowstones, and shales.
	Carboniferous Limestone	Massive limestone, with shale and thin beds of limestone at top.	

Igneous.

A. Interstratified, or contemporaneous with the formation among which they lie.
Tuffs and agglomerates in the upper part of the Carboniferous Limestone.

B. Intrusive or subsequent in date to the formations among which they lie.
Basalt and dolerite in dykes traversing the Carboniferous and Triassic formations.

The district occupied by the coalfields of North Staffordshire is situated at the south-western termination of the Pennine Chain—so well known as forming the backbone of England. This elevated tract, though consisting in the main of one great anticlinal uplift, of which the core is composed of the periclinal Carboniferous Limestone massif

[1] See footnote *ante*.

of the Derbyshire Hills, and off which newer Carboniferous rocks continue to succeed each other, until on its eastern flanks in Derbyshire and on its western flanks in Staffordshire the Coal-measures of the respective coalfields crop out, is in reality made up of several lesser anticlinals consisting in modern technical language of an 'anticlinorium.' It is within the troughs between these saddles that the Coal-measures constituting the Cheadle, Shaffalong, and Pottery Coalfields, and the smaller basin of Goldsitch Moss have been preserved. Moreover, the shape of the fold has determined that of the coalfields. Thus the Cheadle Coalfield is somewhat oval in shape; that of Shaffalong long and narrow; while the Pottery Coalfield is of a triangular form, owing to the fold contracting rapidly in the north and widening out in the south. To this basin there succeeds on the west side of the coalfield a conspicuous anticline composed of Coal-measures in the south and of Lower Carboniferous rocks in the northern part of the district.

The area, especially the Pottery Coalfield, has been further complicated by numerous dislocations, frequently of very great magnitude, which, it will be observed, do not affect the overlying Triassic rocks to anything like the same extent. These disturbances consist, on the east side of the Pottery Coalfield, of a belt of highly inclined strata, bordering the coalfield, and ending at Hulme in a series of fractures which depress the Coal-measures over 200 yards to the east; in the central portion of the coalfield the Apedale Fault, which at one spot attains the magnitude of over 600 yards, plays a still more important part in the coal-mining industry of the district by introducing a broad belt of barren measures beneath which coal-seams lie at considerable depths; while on the western side a fault of even greater magnitude extends along the whole length of the district, and for the present forms the limit of all coal workings in this direction.

Between the closing of the Carboniferous and the opening of the next geological epoch—the Trias—a vast interval of time elapsed, of which the extent will be realised when it is stated that the major part of the folding and faulting took place before the newer formation was laid down. In addition, huge masses of Carboniferous strata were removed; and it is on the denuded edges of these frequently highly inclined rocks, or in the deep hollows worn into them, that the Red Rocks of the Trias resting indiscriminately on the older formation were almost horizontally deposited. Such is the disposition of the Red Rocks on the eastern and southern margins of Pottery Coalfield; but on the west the junction of the two systems is, for the most part, a clearly defined line determined by the fault previously mentioned. Space precludes our giving a longer notice, but we cannot pass by this memoir without expressing our pleasure at the progress of the work of the Survey in the last decade, and the great improvement which has taken place in the style of the later publications, and especially in the quality of the plates and illustrations which accompany the text in the present excellent memoir, the price of which is fixed at six shillings.

REPORTS AND PROCEEDINGS.

Geological Society of London.

April 19th, 1905.—Horace B. Woodward, F.R.S., Vice-President, in the Chair. The following communications were read:—

1. "The Blea Wyke Beds and the Dogger in North-East Yorkshire." By Robert Heron Rastall, B.A., F.G.S.

The author describes the type-section at Blea Wyke in detail, dividing the rocks into the following divisions, enumerated in descending order:—

		ft.	in.
5.	Dogger	11	6
4.	Yellow Beds	53	0
3.	*Serpula* Beds	10	6
2.	*Lingula* Beds	32	0
1.	*Striatulus* Shales.		

Descriptions and fossil lists from these divisions are given, and then the succession is compared with that shown at Peak Alum Works, Saltwick and Whitby, Sandsend and Kettleness, Boulby Cliff, Falling Foss and Littlebeck, Eskdaleside and Grosmont, Glaisdale, and along the north-western escarpment of the Cleveland Hills. A complete series from the Lias to the Lower Estuarine Series is seen only at Blea Wyke; at other sections the transition from Alum Shale to Dogger is abrupt, and the characteristic passage-beds are absent. In all these sections there are signs of unconformity, and in most cases there is a well-marked pebble-bed of peculiar character. In many localities the upper surface of the Lias is worn into distinct hollows, in which lenticular masses of sandstone have been deposited. Probably shallow-water conditions and strong currents prevailed over a wide area. This was most likely brought about by a slow elevation which was more prominent in the northern part of the area, as though the Peak Fault were partly of pre-Oolitic date. This fault probably formed a submarine cliff, and in the still waters at its foot the Blea Wyke passage-beds were formed. North of the fault erosion was active, planing down the Lias to a more or less level surface, with occasional deep hollows due to strong currents. Eventually the upward movement ceased, and the hollow below the fault was filled up, so that the Dogger was laid down as a continuous bed over the whole area. The uplift to the north was probably much greater; consequently the whole of the Upper Lias was removed, and the Middle Lias reached and denuded. Pebbles derived from the Middle Liassic Ironstone occur in the basement conglomerate of the Wainstones, according to Prof. P. F. Kendall.

2. "Notes on the Geological Aspect of some of the North-Eastern Territories of the Congo Free State." By Gaston Félix Joseph Preumont. (Communicated by John Allen Howe, B.Sc., F.G.S.) With Petrological Notes by J. Allen Howe, B.Sc., F.G.S.

This paper is a brief sketch of the geological structure of the northern part of the Congo State, from Buta on the River Rubi and Bima on the Uelle in the west, to Lado and Dufile on the Nile.

In the whole of this region, the only post-Primary rocks met with, other than those of comparatively modern alluvial origin, were chocolate-coloured shales (Buta Shales) and sandstone, and an oolitic limestone, on the extreme west.

From the Lipodongu Falls on the Rubi, and thence through Poko to Rungu, on the Bomokandi River, none but granitic rocks (gneisses) were observed. Along the Uelle, from Bima to Bomokandi, the same rocks were seen.

In the centre of the region mica-schists, quartzites, and similar metamorphic rocks replace the granite wholly or in part. A noticeable feature here is the presence of a range of isolated hills, composed almost completely of great beds of magnetite and hæmatite occurring in the schistose series.

In the south-eastern portion of the region visited, between the Uelle-Kimbali and Bomokandi Rivers, a great plutonic massif is laid bare in the mountainous district of Arebi.

From the presence of iron-ore and schists at Mount Tena on the south-west and analogous rocks at Mount Gaïma on the north-west side of the massif, and from the fact that the dip is in each case strongly away from the intervening country, it is suggested that these rocks have been uplifted and tilted by the plutonic complex, and that the beds of Mount Tena and Mount Gaïma are identical in age.

The plutonic massif itself contains microclinic gneiss and abundant diabasic rocks, and the same rocks in all stages of dynamo-metamorphism.

On the boundary between the Congo State and the Bahr-el-Ghazel several hills made up of rocks of coarse gneissose and schistose character are described; some of these rocks are rich in tourmaline, kyanite, and garnet in large crystals.

From the region of the Enclave de Lado and the western side of the Nile between Lado and Dufile, mica-schists, quartzites, and microcline-gneisses are described.

The alluvium of a large part of the Uelle is covered, on the higher ground, by a deposit of limonitic conglomerate; in places this may be due to the decomposition *in situ* of the alluvium, but in the neighbourhood of the iron mountains a sort of passage may be seen between a conglomerate of fresh iron-ores and the more general type of limonitic conglomerate (laterite?).

CORRESPONDENCE.

THE DISCOVERY OF THE SOUTH-EASTERN COALFIELD.

Sir,—In the last edition of "The Coalfields of Great Britain" Professor Hull gives an account of the discovery of the above coalfield which cannot, in the interests of fairness and truth, be allowed to pass current without correction.

"The credit," he writes (p. 282), "of experimentally demonstrating the existence of coal-seams below the Chalk is due to Mr. Francis

Brady, Engineer of the Channel Tunnel, under the advice of Professor Boyd Dawkins, F.R.S., and an experimental boring was commenced in a position at the foot of Shakespear's Cliff, near Dover, in 1895–6."

It would be difficult to compress more errors into one sentence than are in the above quotation. The only statement which is true relates to the place of the boring. The credit of experimentally proving the existence of the coalfield is not due to Mr. Francis Brady, but to Sir Edward Watkin, Chairman both of the South-Eastern Railway and of the Channel Tunnel Company, who acted under my advice, and sent on to me all reports connected with the boring. Mr. Brady was simply engineer in charge of the borehole, and acted under Sir Edward Watkin's instructions. I never had occasion to advise Mr. Brady. Nor was the boring "commenced in 1895–6." It was begun in 1886, and from that time down to the discovery of the Coal-measures in 1890, the work of identifying the specimens and fixing the horizons of the strata penetrated—or, in other words, all the geology—fell to me. The last of a long series of reports to Sir Edward Watkin is dated July 8th, 1891.

All this is ancient history. The progress of the boring was recorded by me, from time to time, in the Reports of the British Association (1887, 1890, 1899), and in the publications of the Royal Institution (June 6th, 1890) and of the Manchester Geological Society (1890–3–4–7). They also were communicated to the public at large in *The Contemporary Review* (April, 1890), in *Nature* (March 6th, 1890), *The Colliery Guardian*, and *The Iron and Coal Trade Review*. Nor is the attribution of the credit to the wrong man new. An attempt was exposed as far back as 1897, after a full debate before the Manchester Geological Society, in which Sir Edward Watkin's claim was amply vindicated. Still later the history of the discovery was dealt with in my statement on the Buried Coalfields of Southern England, prepared at the request of the Royal Commission of Coal Supplies in 1903 (Final Report, pt. x, p. 28).

It is not, therefore, from lack of sources of information that Professor Hull has written the above paragraph in a work which professes to give the last word on British coalfields. I write this in justice to the memory of an old friend, who proved the truth of Godwin-Austen's theory by practical experiment, the first of a series which is likely to yield, in the future in Kent, important economic results, similar to those brought about in the past by similar borings in Northern France and Belgium.

W. Boyd Dawkins.

Manchester.
May 5th, 1905.

MOUNTAIN-BUILDING.

Sir,—The theory that mountainous areas have been produced by lateral thrust crushing and compressing large areas of country is, I think, now generally accepted; for it has been proved that such mountainous regions as have been carefully surveyed are found to

have the strata bent and folded in such a manner as to cover a much smaller area of country than that upon which they must have been deposited. It has not, however, yet been conclusively demonstrated how such thrust is produced. The hypothesis that cooling and consequent contraction is a sufficient cause has been shown to be untenable; the amount of compression such a contraction is capable of producing being quite insufficient to cause the amount of rock-folding required to produce our great mountain ranges.

As far as I am aware, no other theory based upon a possible reduction in the diameter of the earth has been advanced which seems satisfactory. In default of such an explanation I would suggest that we assume that over large areas of the earth's surface there is an actual expansion of the crust, such expansion compressing the weaker portions into the folds forming mountain ranges.

A probable cause of such an expansion of the crust I should like to draw attention to. It may, perhaps, have been suggested before, but if so I do not remember to have seen it.

As profound changes in the physical features of the earth's surface have been produced by apparently insignificant agencies, we must be prepared to find that some agency which at first sight seems quite inadequate is really the one which is producing the results.

A simple experiment will illustrate the theory I wish to suggest for consideration. If a strip of thin sheet lead have two lines drawn across it near the ends, and it be rolled up into a coil about one inch diameter, and then flattened out again, the bending will be found to have lengthened it about 0·2 per cent., and each time the operation is performed further lengthening will be produced. If continued flexure is capable of expanding slips or sheets of lead and many other materials, it may be argued that the earth's crust may undergo extension under the slight flexures the sun and moon produce. Under such flexure it is conceivable that vertical joints might have mineral matter thrown down in them, as they partially opened and closed, and mineral veins of various kinds be thus formed. Or when the pressure at any point is relieved by flexure, matter previously in solution might be thrown down and not be redissolved when the pressure again came on.

It would be interesting to consider the relationship mountain ranges bear to the great plains where it is conceivable expansion is taking place and to the positions of maximum distortion the sun and moon could produce. Some connection there certainly appears to be between the positions of mountain ranges, the great plains, and the direction of the axis of the earth.

As the moon always presents the same face towards us, unless the sun would be a sufficient cause, there should be no great mountain ranges similar to those on the earth. Indeed, on the moon the surface features are apparently produced by volcanic eruptions and ejections of rock or dust into a very attenuated atmosphere.

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